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ABSTRACT

This instructor's guide contains materials for teaching the steering and suspension specialist component of a competency-based instructional program for students preparing for employment in the automotive service trade. It is based on National Institute of Automotive Service Excellence task lists. The six instructional units contain materials designed to teach students to perform prealignment inspections, adjust wheel alignment, and service the following: tapered roller wheel bearings, steering systems, front suspension systems, and rear suspension systems. Each unit includes the following: performance objectives, suggested activities, pretests, information sheets, assignment sheets, job sheets and their practical tests, written tests, and answers to all tests and assignments. Some units also include handouts, supplements, transparency masters, and activity sheets. Transparency masters, handouts, pretests, practical tests, and written tests are included in the instructor edition only. All unit components focus on measurable and observable learning outcomes, and all units incorporate activities to help students master basic skills required for the workplace. In addition, each unit includes information on the following: using the materials for independent study, amounts of material to cover in single class periods, skills that must be demonstrated, supplies/equipment needed, amounts of class time required for demonstrations and student practice, supplementary materials to order, and resource people to contact. A basic skills matrix correlates competencies and skills. (MN)

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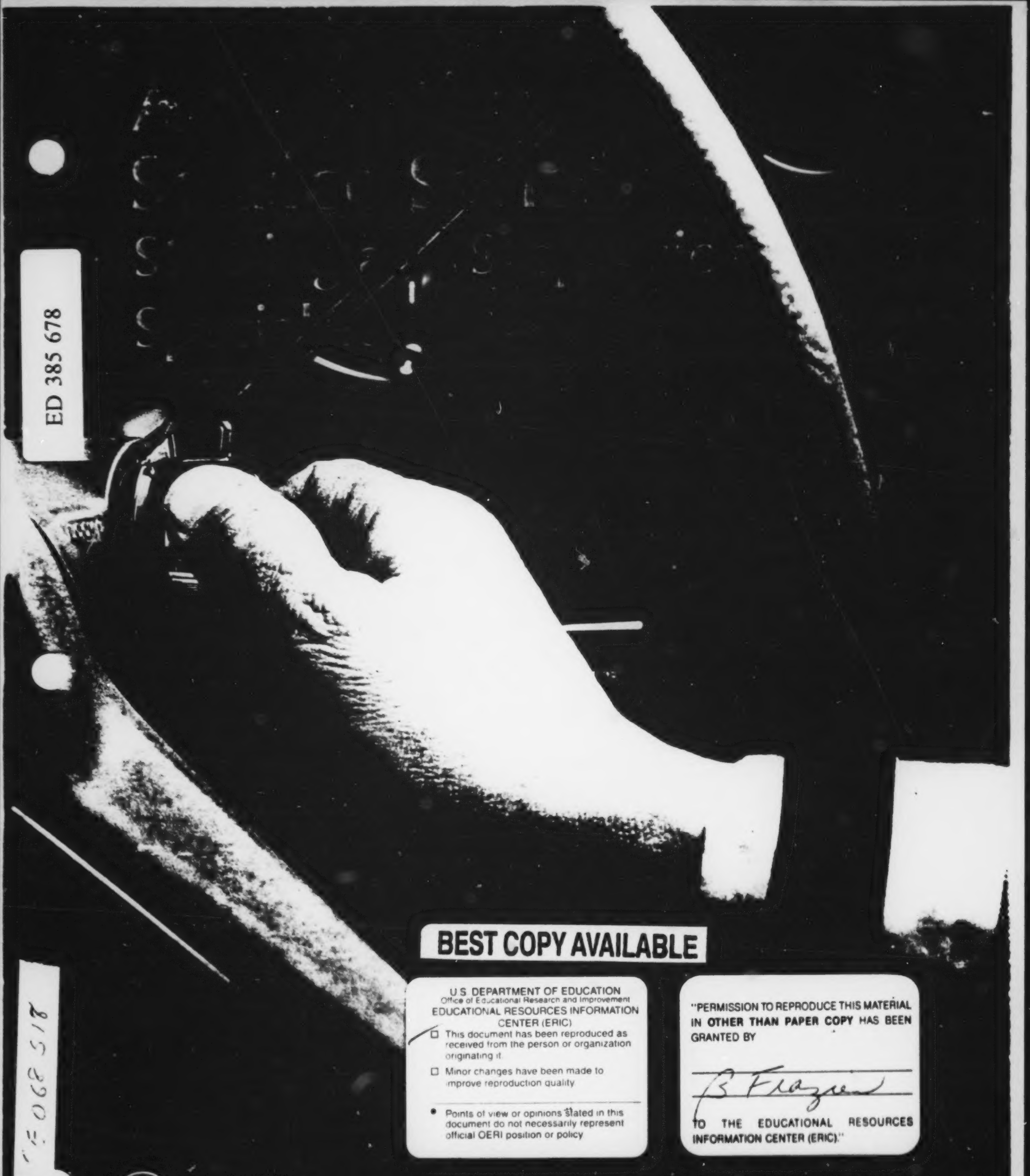

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CIMC

Teacher Edition

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Oklahoma Department of
Vocational and Technical Education
1500 West Seventh Avenue
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TI 1228

Steering and Suspension Specialist

Developed by the
Curriculum and Instructional Materials Center
for the Division of Trade and Industrial Education
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Steering and Suspension Specialist

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FOREWORD

This is one in a series of eight automotive service specialty publications that is based on the National Institute of Automotive Service Excellence (ASE) task lists. This series provides instruction for all high-priority competencies established by ASE and will contribute greatly to an auto service technology program's ability to meet the requirements of a nationally certified training school.

The ASE competencies are developed by industry to meet the industry's need for quality technicians. This curriculum addresses that need. The industry and education committee that has validated the technical accuracy of this material is commended for outstanding service and commitment to the quality of these instructional units. The instructors and students who use this material are challenged to have the same commitment to excellence.

We trust that this instructional material will meet students' needs as they prepare for careers in steering and suspension service.

Dr. Roy Peters, Jr.
State Director
Oklahoma Department of
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Ivan Armstrong
State Supervisor
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PREFACE

The purpose of *Steering and Suspension Specialist* is to continue the students' training in the automotive service trade by providing instruction in this specialty area. This publication is one in a series of eight publications for automotive specialty areas. Other areas included in this series are brakes, manual drivetrain and axles, engine repair, engine performance, electrical, heating and air conditioning, and automatic transmission/transaxle.

Instructors are faced with the challenge of teaching the skills and related information necessary for their students to become the highly-qualified automotive service specialists that are in demand today. This curriculum is designed to help instructors meet this challenge. The objectives in this curriculum are based on those National Institute of Automotive Service Excellence (ASE) tasks that are required of an automotive steering and suspension technician.

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ACKNOWLEDGEMENTS

The Curriculum and Instructional Materials Center (CIMC) extends its appreciation to those individuals who played important roles in the development of *Steering and Suspension Specialist*.

Special appreciation is extended to the vocational educators who so generously contributed their substantial expertise, talents, and time to serve on the *Steering and Suspension* curriculum validation committee.

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We also want to thank the state director, Dr. Roy Peters, Jr., and assistant state director, Dr. Charles O. Hopkins, for their continued support throughout this project.

Oklahoma Department of Vocational and Technical Education Trade and Industrial Education staff who provided leadership and direction on this project also deserve special recognition:

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Only through the close cooperation of the Curriculum and Instructional Materials Center staff was this curriculum developed. Sincere thanks are shared with the current as well as former CIMC coordinators.

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Development Coordinator (current)

Mr. Greg Pierce
former CIMC Coordinator

Ms. Sheila Stone
former Development Coordinator

Special appreciation is offered to the individuals on the CIMC staff who functioned in important roles throughout the development of the *Steering and Suspension Specialist* curriculum: Marsha Sneed, who did the research and wrote the preliminary text; Vicki Elias, who did the rewrite; Connie Romans who edited the illustrations and assisted with the text edit; Camille Baker and Carl Rose who assisted with editing; and Charlotte Tarkington, who assisted with the permission letters for the illustrations. Thanks also to the many other members of the CIMC staff who so generously provided the support, help, and advice that was needed for this project.

Special recognition and thanks are also extended to other individuals within the Oklahoma Department of Vocational and Technical Education involved in the development process: Rose Primeaux in the Word Processing Center; Bob Davis and his staff in the Art Department; Noel Wilcoxson, Duane Foster, and Diane Ensign and their staffs at the ODVTE Print Shop; Karen Williams, Denise Dow, and Lois Heid in the Resource Center.

And finally, a very special acknowledgment goes to Chuck Pendergast, the technical advisor for this project, without whose expert collaboration, advice, support, review, and encouragement this curriculum would not have been possible.

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USE OF THIS PUBLICATION

INSTRUCTIONAL UNITS

Steering and Suspension Specialist contains six units. Each instructional unit includes basic components that form a unit of instruction: performance objectives, suggested activities, pretests and pretest answers, information sheets, assignment sheets and assignment sheet answers, job sheets and their practical tests, and written tests and written test answers. Handouts, supplements, transparency masters, and activity sheets are optional components which may be included in some or all of the units. Transparency masters, handouts, pretests, practical tests, and written tests are included in the instructor edition only and may be duplicated for classroom use. Test packets may be purchased in Oklahoma by calling 1-800-522-5810. Out-of-state instructors may order test packets by calling 1-800-654-4502.

The unit components focus on measurable and observable learning outcomes. Instructors are encouraged to supplement, personalize, localize, and motivate with these materials in order to develop a complete teaching/learning process.

Units of instruction are designed for use in more than one lesson or class period of instruction. By carefully studying each unit of instruction, the instructor will be able to plan presentations and demonstrations to meet the needs of the students as well as determine the following:

- How to use the materials for independent study
- Amount of material to cover in a single class period
- Skills that must be demonstrated
- Supplies and equipment needed
- Amount of class time required for demonstrations
- Amount of class time required for student practice
- Supplementary materials to order, such as pamphlets, videos, or software
- Resource people to contact

Objective Sheets (White Pages)

Each unit of instruction is based on the knowledge and skills needed for successful employment in an occupational area. What the student must know and be able to do has been translated into performance objectives which are stated in two forms. ***Unit objectives*** state the subject matter to be covered in a unit of instruction, what the student should be able to do and what standard will be used to determine whether the student has achieved competency. ***Specific objectives*** outline the teaching sequence and state the performance necessary to meet the unit objective.

The objectives can also help determine teaching strategies and instructional methods. Instructors will need to decide how each objective can best be taught (individualized or class instruction) to their students prior to beginning the unit. Instructors should feel free to modify, delete, or add objectives in order to meet the needs of the students and the community. If objectives are added, the instructor should remember to supply the needed information, assignment sheets, job sheets, practical tests, and criterion test items.

Suggested Activities (Pink Pages) — **Instructor's Edition Only**

This component assists the instructor during the preparation stage of the teaching/learning process by providing suggestions for delivery, enrichment, and application during the instructional process. Teaching suggestions are included for each objective. The instructor should read the suggested activities before teaching the units to allow time to obtain supplemental materials, prepare audiovisual materials, and contact outside resources. Duties of the instructor will vary according to the particular unit.

Included in this component are suggested resources of books, audiovisual materials, and software which may be used to teach the unit. References used in the development of each unit are also provided. Instructors can use suggested resources and unit references to supplement their knowledge of the subject or to help students with particular interests or occupational objectives in the subject area.

Handouts (White Pages) — **Instructor's Edition Only**

Handouts are additional teaching aids that support portions of the information sheet by providing "nice-to-know" information which is not testable. They may include activities such as games, puzzles or supplementary information on subjects that are considered to be controversial. The instructor may decide whether to duplicate and use handouts in teaching the unit.

Pretests (Yellow Pages) — **Instructor's Edition Only**

Because students bring a variety of background experiences and knowledge to the classroom, pretests are included to allow the student the opportunity to demonstrate previously gained information. The pretest provides a criterion-referenced tool for evaluating students' knowledge prior to studying the unit. For a description of this component, please refer to the written test description.

Pretest Answers (Pink Pages) — **Instructor's Edition Only**

This component is designed to assist the instructor in evaluating student performance on the pretest.

Information Sheets (Green Pages)

The information sheets provide "must know" content that is essential for meeting the cognitive objectives. The information sheets serve as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective.

Students should read the information sheets before the information is discussed in class. Space is provided in margins for students and instructors to add notes that supplement, localize, personalize, or provide motivation for each unit. Program coordinators, directors, and/or instructors are encouraged to select and acquire textbooks for students in order to supplement and expand the material covered in the information sheets.

The information sheets may include notes, cautions, or warnings. These should be discussed carefully and thoroughly. ***Notes*** are short verbal additions to the information that provide nice-to-know and decision-making information. A note may tell the student what to look for or consider at a given step or may explain when a step may not be applicable. Notes offer guidance that may help the student understand the process and accomplish it more efficiently. ***Cautions*** are advisories that alert students to conditions or situations which may result in physical damage to themselves, the vehicle, or equipment. ***Warnings*** are advisories that alert the student to dangers which may result in critical or fatal damage to themselves or major damage to the vehicle or equipment.

Supplements (Green Pages)

Supplements include material that provides additional information for understanding the topic but may not have direct application to specific objectives. Instructions that might be used for solving problems, tables, charts, written information, forms, or other information students might need in order to complete one or more of the assignment or job sheets could be included as a supplement. While information in supplements is not tested directly, it may be used to assist the student in meeting the performance objectives.

Transparency Masters (White Pages) — **Instructor's Edition Only**

Transparency masters provide information in a special way. They direct the class's attention to the topic of discussion and allow the instructor to illustrate the topic. The use of transparencies is especially effective for visual learners who prefer to see the topic being presented as well as hear about it. Transparencies may present new information or they may reinforce information presented in the information sheets. Transparencies should be made ahead of time and placed with the rest of the materials necessary to teach the unit.

Activity Sheets (Tan Pages)

Activity sheets provide activities which support several objectives or deal with students' attitudes, beliefs or appreciation of the study area. Some may ask rather personal questions and are only intended for each student's personal use while other activity sheets may require the student to monitor his or her own actions or other personal variables over a period of time. Activity sheets will vary greatly in their design from unit to unit. When Activity Sheet Answers (pink pages) are provided, they are found only in the Teacher's Edition.

Assignment Sheets (Tan Pages)

Assignment sheets provide written exercises for instruction and practice of a specific objective. The introduction to the assignment sheet explains how the assignment sheet relates to the subject area and unit objectives and may provide instructional information or refer students to another component for such information.

Assignment sheets are intended to provide students with practice in exercising higher-order thinking skills. Often assignment sheets will contain case studies, story problems, or other situations in which the student must analyze the circumstances and determine correct responses. Students may be given assignment sheets in class or as homework.

Assignment Sheet Answers (Pink Pages) — **Instructor's Edition Only**

This component is designed to assist the instructor in evaluating student performance on assignment sheets.

Job Sheets (Blue Pages)

Job sheets provide a list of equipment, tools, and materials needed to complete a manipulative or psychomotor skill. They describe a step-by-step procedure to complete each task or job. Diagrams, photographs, and illustrations may be included to assist students in achieving the skill.

The instructor should demonstrate the procedures outlined in each job sheet. Furthermore, the instructor needs to localize the procedure according to the equipment and supplies available in the local lab situation. Job sheets also show potential employers what skills the students are learning and the performances they might reasonably expect from students who have had this vocational instruction.

Practical Tests (Yellow Pages) — **Instructor's Edition Only**

Practical tests assist the instructor in evaluating the psychomotor activities (job sheets). The practical tests provide instructors with a valid mechanism for determining a student's level of ability to perform the procedure stated on the job sheet and a means of evaluating the student's final product.

Written Tests (Yellow Pages) — **Instructor's Edition Only**

This component provides criterion-referenced evaluation of every objective listed in the unit of instruction. All performance objectives will be evaluated. If objectives have been added, deleted, or modified, appropriate changes should be made on the written test.

The tests may be written or oral. It may be advisable to divide the tests into shorter tests covering three or four objectives at a time and give them soon after those objectives are covered.

The acceptable response on a written test, eighty-five (85) percent in most units, applies to the overall score, not to each individual question. The final unit grade should be obtained by combining written test and assignment sheet scores with evaluation ratings on the practical tests.

Written Test Answers (Pink Pages) — **Instructor's Edition Only**

This component is designed to assist the instructor in evaluating student performance on the written test.

PAGE NUMBERING

Each publication for the CIMC is assigned a specific abbreviation or will be recognized by the book title. *Steering and Suspension Specialist* will be referred to by "MDT." Each unit is identified by the unit number in Roman numerals followed by the page number. The first page of each unit is always page 1. The component name, book title, unit number, and page number within the unit are printed at the bottom of each page. An example of the page footer for an objective sheet in *Steering and Suspension Specialist* is shown below.

OBJECTIVE SHEET - SS
I - 1

METHODS OF DISSEMINATING MATERIAL

Each student should be provided with a student workbook. Workbooks may be purchased for less than an instructor can reproduce them, especially when the instructor's time is considered. Student workbooks contain everything but the suggested activities, pretests, pretest answers, handouts, transparency masters, activity sheet answers, assignment sheet answers, practical tests, written tests, and written test answers. Test packets may be purchased from the Curriculum and Instructional Materials Center. Students should be allowed to take their workbooks home when they complete the program.

TEACHING METHODS

It is a challenge to keep students motivated. Instructors can supplement the objectives by providing the "why," personal experiences, and current information. Preparation for each unit should be determined by how each objective can best be taught. Students should become involved in preparing and planning for each unit.

If the material will be utilized in an individualized instruction situation, instructors should provide opportunities that will allow students to become involved in planning for and being responsible for their own education.

COMPETENCY PROFILES

A competency profile is available for each CIMC publication. Competency profiles document student performance. The profile contains a list of the specific job competencies that a student should achieve before leaving the training program. Profiles should be distributed to students as needed.

DISCLAIMERS, CORRECTIONS AND SUGGESTIONS

Materials

Please note that suggested resources and references listed in this publication existed when this publication was written. CIMC assumes no responsibility for providing these materials and cannot ensure the availability of these materials as individual vendors, manufacturers, and publishers may discontinue these products at any time.

Safety

The Curriculum and Instructional Materials Center (CIMC) wants to provide vocational instructors and students with materials that are accurate and effective. Although the CIMC strives to maintain the highest standards of development and production, oversights occasionally do occur. The CIMC assumes no responsibility for any adverse effects resulting directly or indirectly from information, suggested procedures, undetected errors or the reader's misunderstanding of the information presented.

Corrections and Suggestions

If you find any errors in this or other CIMC publications or have suggestions for improving their usefulness in vocational programs, please notify the CIMC staff. One easy way of pointing out errors is to make a photocopy of the affected page and to indicate the correction on the copy. Mail this information to the CIMC, where it will be used to correct the publication before the materials are reprinted.

To ensure that the material is updated on a timely basis, notify the CIMC of necessary corrections as soon as possible after discovering the error. Do not assume that someone else will notice the error and inform the CIMC; other users may be making the same assumption. Please send corrections and recommendations for improving this publication to the following address:

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Technical Education
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BASIC SKILLS IN CIMC MATERIALS

Preparing students to enter successfully into today's world of work offers vocational education a substantial challenge. The contemporary workplace is characterized by constant and rapid technological change and by increasing job complexity and skill intensity. Due to rapid technological advancement, the half-life of work skills is now reduced to a bare three to five years. Out of this new workplace environment has arisen a growing awareness of the critical importance of an American workforce armed with the skills necessary to survive in a competitive economy.

One result of this national awareness has been the emergence of a renewed emphasis on basic academic skills in all areas of education. Pressure to increase academic skill development is being placed on education by both legislative action and industry mandate. The Carl D. Perkins Vocational and Applied Technology Education Act of 1990 sets stringent basic skill requirements for vocational education. State legislatures are increasingly requiring basic skills accountability by teachers and school administrators. Graduation exams, minimum competency requirements, and expected learner outcomes are being implemented with increasing frequency. In addition, business and industry are delivering the message clearly to educators that vocational competence now requires increased strength in the basic skills.

The issue of the basic skills currently required in the work place was very successfully addressed in a recent national three-year study conducted jointly by the American Society of Training and Development (ASTD) and the U.S. Department of Labor (DOL). The findings of this study were published in 1990 in the book, *Workplace Basics: The Essential Skills Employers Want.*

The ASTD/DOL research indicates clearly that American employers have discovered that their workforces need a variety of skills that include, but are not limited to, the classic academic trio of reading, writing, and computation. Employers now are also looking for competence in areas such as "learning to learn," problem solving and critical thinking, interpersonal and teamwork skills, oral communication and listening techniques, and the social and personal management skills that demonstrate a capacity for independence and responsibility in on-the-job performance.

It is clear that the requirements of today's business and industry have expanded and re-defined "workplace basics." It is in line with the re-definition and with the competency requirements of current education legislation, that the Oklahoma Department of Vocational and Technical Education has chosen to address "basic skills" in the instructional materials produced by its Curriculum and Instructional Materials Center.

It is not a new development for CIMC materials to contain information and activities which develop basic skills competencies in students undertaking vocational programs. What is new is the specific marking, or flagging, of items in our instruction materials that address basic skills.

To assist teachers and students in identifying activities which promote basic skills development, CIMC has implemented a marking system which uses simple graphic symbols or icons. These icons are located in the left margins of assignment sheets, activity sheets, and job sheets. The following is an explanation of the icons and the kinds of basic skill activities they indicate.

1. **READING SKILLS:** Skills involving use of print resource material for obtaining and applying information.

Current vocational education literature indicates that functional literacy as a workplace basic needs to be defined in terms of reading competencies actually required for job performance. The activities identified with this icon addressing reading skills in CIMC materials deal specifically with developing reading skills in an applied, job-related context. These range from general information-gathering activities to tasks requiring use of specific technical reference materials. Many contain a "learning to learn" aspect which promotes engaging actively and purposefully in vocationally relevant inquiry.

2. **WRITING SKILLS:** Skills involving written communication of processes, information, or ideas.

Tasks identified with this icon promote development of skills in written communications. As with reading skills, the writing skills emphasized in CIMC materials have a vocational context. They include filling out forms, keeping work activity records, writing simple memos and letters, generating more complex reports and articles, and written expression of ideas and concepts related to vocational performance or exploration.

3. **MATHEMATICS SKILLS:** Skills involving computation, calculation, and interpretation of numerical data.

This icon identifies activities which develop vocationally-related skills in computation, measurement and estimation, selection and application of appropriate mathematical processes, and collecting, displaying, or interpreting data.

4. **SCIENCE SKILLS:** Skills involving mastery and application of scientific information or theory.

This icon marks activities which are related to the development of skills in either the physical or biological sciences. These skills stress occupationally-related application of science and technology.

5. **ORAL COMMUNICATION SKILLS:** Skills involving speaking and listening.

Activities marked with this icon promote development of effective speaking and listening. They include practice in such areas as speaking techniques, word choice, non-verbal messages, use of communication media, and using active listening techniques. Many of these activities promote "learning to learn" skills in verbal inquiry.

6. **INTERPERSONAL OR RELATING SKILLS:** Skills involving working and getting along with others.

Activities which deal directly with skills in relating to others are marked with this icon. This includes areas such as multi-cultural awareness, group processes and dynamics, negotiation, dealing with conflict, cooperation and teamwork, values and attitudes, and leadership and motivation.

7. **CREATIVE THINKING AND PROBLEM SOLVING SKILLS:** Skills involving comprehending, applying, analyzing, and developing complex ideas and situations.

This icon identifies activities which stress development of higher-order thought processes such as problem identification and analysis, lateral thinking, evaluating alternatives, developing solutions, examining assumptions, and evaluating outcomes.

8. **EMPLOYABILITY SKILLS:** Skills involving choosing, obtaining, and succeeding in a career.

Activities marked with this icon relate to competencies required to obtain employment and develop a career. These competencies include specific occupational tasks. They also include items such as career analysis and selection, job searching, completing applications and resumes, interviewing, business etiquette, and personal management skills required for job-keeping and maturing in one's work. Examples of the later category include personal presentation, self-discipline, work accuracy, reliability, discretion, punctuality, handling stress, judgment, confidence, etc.

9. **SOCIAL STUDIES SKILLS:** Skills involving investigation and application of social concepts.

This icon marks activities which stress competencies in fields relating to human society and its distribution and relationships. This includes areas such as history, geography, demographics, current events, cross-cultural studies, consumer issues, environmental issues, and ethical concerns in science and technology.

Some activities in CIMC materials develop skills in more than one of the eight basic skill areas. In cases where the relative strengths of the skill elements are clearly discernable, the identification icon used is the one judged to be the primary, or strongest, element in the activity. For some activities, more than one icon is used, indicating equal strength of basic skills components in the activity.

The use of graphic icons to identify basic skills in CIMC instructional materials is the first in a series of steps designed to foster basic skills development in vocational students and accountability for vocational teachers. The Oklahoma Department of Vocational and Technical Education has developed a staged implementation strategy for integrating basic skills into CIMC materials. Additional basic skill elements in future CIMC publications will reflect the advancement of this staged implementation

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OBJECTIVE SHEET

SERVICE TAPERED ROLLER WHEEL BEARINGS

I

INTRODUCTION

Wheel bearings are an integral part of the wheel assembly. Many vehicle owners do not realize the importance or understand the purpose of wheel bearings. Wheel bearings allow the wheel to turn freely. The difficulties encountered when servicing wheel bearings frequently occur during the removal of assemblies such as the hub and rotor and the brakes to gain access to the bearings. When removing wheel components, always be careful not to damage the anti-lock brake sensors, if the vehicle is so equipped. Wheel bearing adjustment is critical since improper adjustment can cause severe wheel bearing or hub damage. The steering and suspension specialist must understand the various types of wheel assemblies available and must be able to properly service the wheel bearings. A background in brake service can be helpful to the steering and suspension specialist because wheel bearings are often serviced during brake system inspection and repair.

PREREQUISITES

Before studying this unit, the student should have successfully completed the core curriculum, *Introduction to Automotive Service*.

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose wheel bearing problems and service wheel bearings. The student will demonstrate these competencies by completing the assignment sheet, job sheets, and written test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to show the ability to:

1. Select the definitions of terms associated with wheel bearings.
2. State the purposes of wheel bearings.
3. Label the parts of a tapered roller wheel bearing assembly.
4. List the properties of wheel bearing grease.
5. Diagnose wheel bearing problems. (Assignment Sheet 1)
6. Demonstrate the ability to:
   A. Adjust wheel bearings. (Job Sheet 1)

B. Remove, clean, inspect, pack, and install non-drive wheel bearings and replace seals. (Job Sheet 2)

SUGGESTED ACTIVITIES

SERVICE TAPERED ROLLER WHEEL BEARINGS

PREPARATION

- Review unit and plan presentation. Study the specific objectives to determine the order in which you will present the objectives.

- Review the teaching suggestions given in the Delivery and Application sections and plan classroom activities. Also note suggestions for media and supplemental materials.

- Plan presentation to take advantage of student learning styles and to accommodate students with special needs.

- Many multiple-choice test questions (in the Pretests, Assignment Sheets, and Written Test) for this curriculum have been written in a style that is similar to the questions on the ASE certification test. Like ASE questions, the student should select the item that **BEST** answers the question. *The student should make no additional assumptions about a question other than those specifically given in the question.* A special effort has been made to provide good distracters for each question which will make the student think through the answer. It is suggested that the instructor review the answers to every test before reviewing the test with the students so that he or she is not caught off guard by such distracters.

- Obtain films, videotapes, and other media to supplement the instruction of this unit. See ordering information in the Suggested Resources section. Include in your selection media that demonstrate job sheet skills. Videotape your own demonstrations of job sheet procedures if you are unable to obtain suitable media.

- Obtain competency profiles.

  NOTE: Competency profiles for this book are available from the Curriculum and Instructional Materials Center, Oklahoma Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364. 1-800-522-5810 ext 589 in-state, 1-800-654-4502 out-of-state.

- Prepare the classroom and shop. Display posters, charts, safety signs, etc., that emphasize wheel bearing service. Have articles, specification guides, mock-ups, and other references about wheel bearing service available for student use. Display various types of wheel bearings.

- Discuss the purpose of pretesting with the students. Explain that they will be asked to complete a written pretest and that they will be required to demonstrate assignment sheet competencies and job sheet skills as part of the pretesting process.

- Provide the students with the equipment and materials necessary to complete the pretest. Administer the pretest.

- Assess student competencies. Consider the results of student assessments of the unit objectives as you prepare your presentation for each objective.

DELIVERY

Unit Introduction

- Discuss the introduction to the unit. (See Objective Sheet.)

- Discuss the unit objective and then the specific objectives. Emphasize how accomplishing the specific objectives will lead to meeting the unit objective and how reaching the unit objective is vital to becoming an automotive steering and suspension technician. Also relate the objective to your introduction and to the material previously covered.

Objective 1 Select the definitions of terms associated with wheel bearings.

- Show the students examples of each of the terms listed in this objective.

- Demonstrate *end play*, *press fit*, *push fit*, and *preload*.

- Display a complete bearing assembly with the parts named.

- Discuss the information in the box labeled "Wheel Bearings."

- Use Handout 1, Wheel Bearing Crossword Puzzle, to reinforce the terms and definitions.

Objective 2 State the purposes of wheel bearings.

- Demonstrate how wheel bearings reduce friction. Show the students how much resistance there is when sliding a heavy object across a surface compared to sliding the same object across the surface on a handful of marbles.

- Discuss the information in the box labeled "Wheel Bearings and Load Lines."

Objective 3 Label the parts of a tapered roller wheel bearing assembly.

- Use Transparency 1, Roller Wheel Bearing Assembly, to illustrate your discussion.

- Display a tapered roller wheel bearing assembly so that students can examine its parts.

- Disassemble a tapered roller wheel bearing assembly, naming and explaining each of the parts as it is disassembled.

- Discuss the information in the box labeled "Types of Wheel Bearings." Show students examples of each of the different types.

- Use Transparencies 2 and 3 to show typical hub assemblies which use tapered roller wheel bearings.

Objective 4 List the properties of wheel bearing grease.

- Review each of the properties listed in this objective, explaining the need for each.

- Have the students read the labels on various brands of wheel bearing grease. Discuss the importance of not mixing different types of greases.

- Demonstrate each of the properties. For instance, show how wheel bearing grease is heat-resistant, water-resistant, and noncorrosive.

- Discuss the information in the box labeled "Wheel Bearing Lubrication."

APPLICATION

Objective 5 Diagnose wheel bearing problems. (Assignment Sheet 1)

- Have the students read Student Supplement 1, Wheel Bearing Problems, and Student Supplement 2, Tapered Roller Bearing Damage Diagnosis Chart. Discuss the usual indications of wheel bearing problems and the causes for the common types of bearing damage.

- Show the students diagnosis charts for brake system problems and steering and suspension system problems. Point out the many conditions that could reflect problems in any of these systems or in the wheel bearings.

- Have the students review Student Supplements 1 and 2, then have them complete Assignment Sheet 1. Discuss the answers in class after the students have completed the assignment.

Objective 6A Adjust wheel bearings. (Job Sheet 1)

- Show the video, *Adjust Front-Wheel Bearings*, and answer any questions students may have.

- Discuss the equipment and materials used in Job Sheet 1. Review with the students applicable safety rules and precautions and the guidelines given in the job sheet introduction.

- Demonstrate Job Sheet 1. Have the students practice Job Sheet 1 until they are ready to take the practical test.

Objective 6B Remove, clean, inspect, pack, and install non-drive wheel bearings and replace seals. (Job Sheet 2)

- Show the video, *Clean and Inspect Bearings* and *Pack Front-Wheel Bearing Assembly*.

- Review the properties of wheel bearing grease outlined in Objective 4 with the students.

- Explain that it is important to replace the grease seal when performing this service, because a faulty seal can allow the newly-packed grease to become contaminated, leading to bearing damage.

- Show the students a disc brake assembly and a drum brake assembly. Use Transparencies 1 and 2 to point out the parts or components that the students may need to remove or adjust when performing wheel bearing service.

- Review the asbestos safety rules that should be followed when working with brake components. Show the video, *Don't Blow It*. Instruct the students on how to properly use the asbestos removal equipment in your shop.

  NOTE: Have a sign-in sheet to insure that all students have viewed the video.

- Review the terms *push fit* and *press fit*. Also review the parts of a tapered roller wheel bearing assembly, explaining that the outer race is called the *cup* and the inner race is called the *cone*.

- Discuss the equipment and materials used in Job Sheet 2.

- Review applicable safety rules and precautions and the guidelines given in the job sheet introduction with the students.

- Demonstrate Job Sheet 2. Have the students practice Job Sheet 2 until they are ready to take the practical test.

Unit summary activity

- Discuss Activity Sheet 1, Answer General Questions About Tapered Roller Wheel Bearings. The purpose of the activity is to provide students with the opportunity to practice answering questions similar in content and style to those found on the actual ASE certification test. Keep this in mind when discussing the activity.

- Use Handout 2.

- Have the students complete Activity Sheet 1.

EVALUATION

- Give the written test.

  NOTE: The written test may be given in sections if desired.

- Evaluate class members on the assignment sheet activities if not previously done. Provide them with copies of Supplement 1, Wheel Bearing Problems, and Supplement 2, Tapered Roller Bearing Damage Diagnosis Chart.

- Give the practical tests and evaluate the tests on the forms provided.

- Reteach and retest as required.
- Complete the appropriate section of the competency profiles.
- Review individual and group performance in order to evaluate teaching methods.
- Adjust the scope, sequence, or instructional approaches for additional lessons as required.

SUGGESTED RESOURCES

Resources used in developing unit

- *Automotive Brake Service, Unit 2, Front Disc Brake Service.* Tallahassee, Florida: State of Florida Department of Education, 1981.
- *Bearings and Seals*, 3rd ed. Moline, Illinois: Deere & Co., 1980.
- *Brakes Specialist.* Stillwater, Oklahoma: Oklahoma Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1989.
- *Chilton's Guide to Brakes, Steering and Suspension 1980-87.* Radnor, Pennsylvania: Chilton Book Co., 1987.
- Coghlan, David A. *Automotive Chassis Systems: Steering, Suspension, Alignment, and Brakes*, 2nd ed. Boston, Massachusetts: Breton Publishers, A Division of Wadsworth, Inc., 1985.
- deKryger, William J., Robert T. Kovacik, and Saverio G. Bono. *Auto Mechanics: Theory and Service.* Cincinnati, Ohio: South-Western Publishing Co., 1986.
- Hughes, James G. *Brakes.* Orlando, Florida: Harcourt Brace Jovanovich, Inc., 1987.
- *Motor Front End & Brakes Manual, Including Rear Suspension.* Troy, Michigan: Hearst Books/Business Publishing Group, A Division of Hearst Corp., 1990.
- *1986 Chrysler Engine-Chassis-Body Service Manual: 1986 Front Wheel Drive Passenger Vehicles Lancer, Daytona, New Yorker, Dodge 600, Aries, Omni, LeBaron GTS, Laser, LeBaron, Caravelle, Reliant, Horizon.* Centerline, Michigan: Chrysler Corp., 1985.

- *1986 Shop Manual: Caprice, Monte Carlo, El Camino.* Detroit, Michigan: General Motors Corp., Chevrolet Motor Division, 1985.
- *1988 Oldsmobile Chassis Service Manual.* Lansing, Michigan: General Motors Corp., Service Department Oldsmobile Division, 1988.
- *Probe Shop Manual.* Ford Motor Co., 1988.
- Remling, John. *Brakes*, 2nd ed. New York: John Wiley and Sons, Inc., 1983.
- Scharff, Robert. *Complete Brake Systems.* Albany, New York: Delmar Publishers Inc., 1989.
- Scharff, Robert. *Complete Undercar Systems: Steering and Suspension.* Albany, New York: Delmar Publishers Inc., 1989.
- Sharp, David. *Automobile Mechanic Certification Tests.* New York: Prentice Hall Press, A Division of Simon & Schuster, Inc., 1985.
- *Wagner Manual AU-1600: Hydraulic Disc and Drum Brake Diagnostic Analysis and Reconditioning Manual.* Parsippany, New Jersey: Wagner Division, Cooper Industries, Inc., 1988.

Media

Spelling and definitions of terminology used in automotive service are not standardized. Media selected to supplement and reinforce material taught in this book may or may not use the same spelling and definitions. Although such deviations should not restrict classroom use of supplemental materials, their existence may confuse some students.

- *Don't Blow It.* 16 minutes, VHS videotape. Available for loan or purchase from Clayton Associates, Inc., P.O. Box 589, Farmingdale, New Jersey 07727-0589, phone 800-248-8650. This videotape demonstrates the proper way to use asbestos-removal equipment to prevent asbestos exposure.

- *Service Brake Hydraulic System and Wheel Bearings.* VHS videotapes. Test the Hydraulic System; Bleed Brake System; Clean and Inspect Bearings; Pack Front-Wheel Bearing Assembly; Adjust Front-Wheel Bearings; Remove Repair, and Replace Tandem Master Cylinder; and Test Vacuum Booster. VHS videotapes. Curriculum and Instructional Materials Center, Oklahoma Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364.

For the most recent information on asbestos safety for those working with automotive brake systems and components, contact the following:

- EPA Region VI
  Internfirst II Bldg.
  1201 Elm Street
  Dallas, Texas 75270
  (214) 767-2734

- National Institute for Occupational Safety and Health
  4676 Columbia Parkway
  Cincinnati, Ohio 45226
  (513) 533-8323

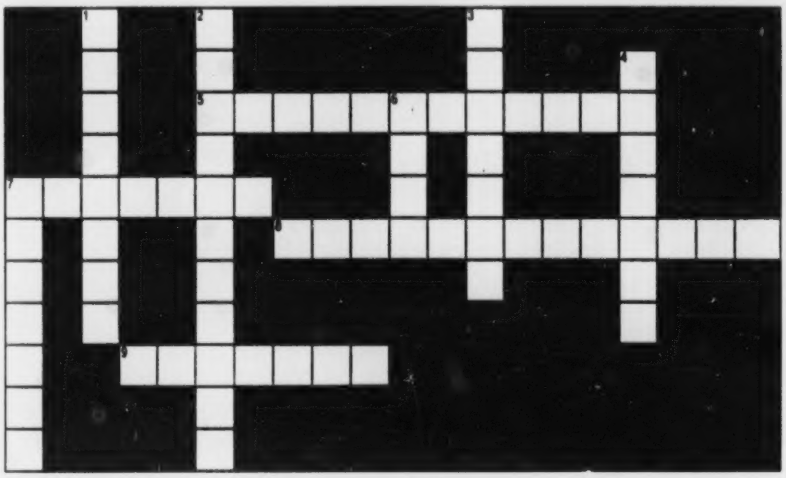
- OSHA Office of Information and Consumer Affairs
  Room N-3637
  200 Constitution Avenue N.W.
  Washington, D.C. 20210
  (202) 523-8151

HANDOUT 1

SERVICE TAPERED ROLLER WHEEL BEARINGS

I

WHEEL BEARING CROSSWORD PUZZLE



DOWN

1. Installation of an outer race (cup) with a tight or interference fit requiring more than hand pressure to install
2. That part of a bearing assembly located on the outer side of the bearing rollers or balls and just inside the hub; installed in the hub with a press fit; also called the *cup*
3. The process of cleaning old grease from bearings and then forcing new wheel bearing grease into the openings between the races and the ball or roller cages
4. Amount of axial movement in a hub due to the clearance in the bearings
6. The surface or path on which bearing balls or rollers move
7. To adjust the bearings so that they will work under mild pressure

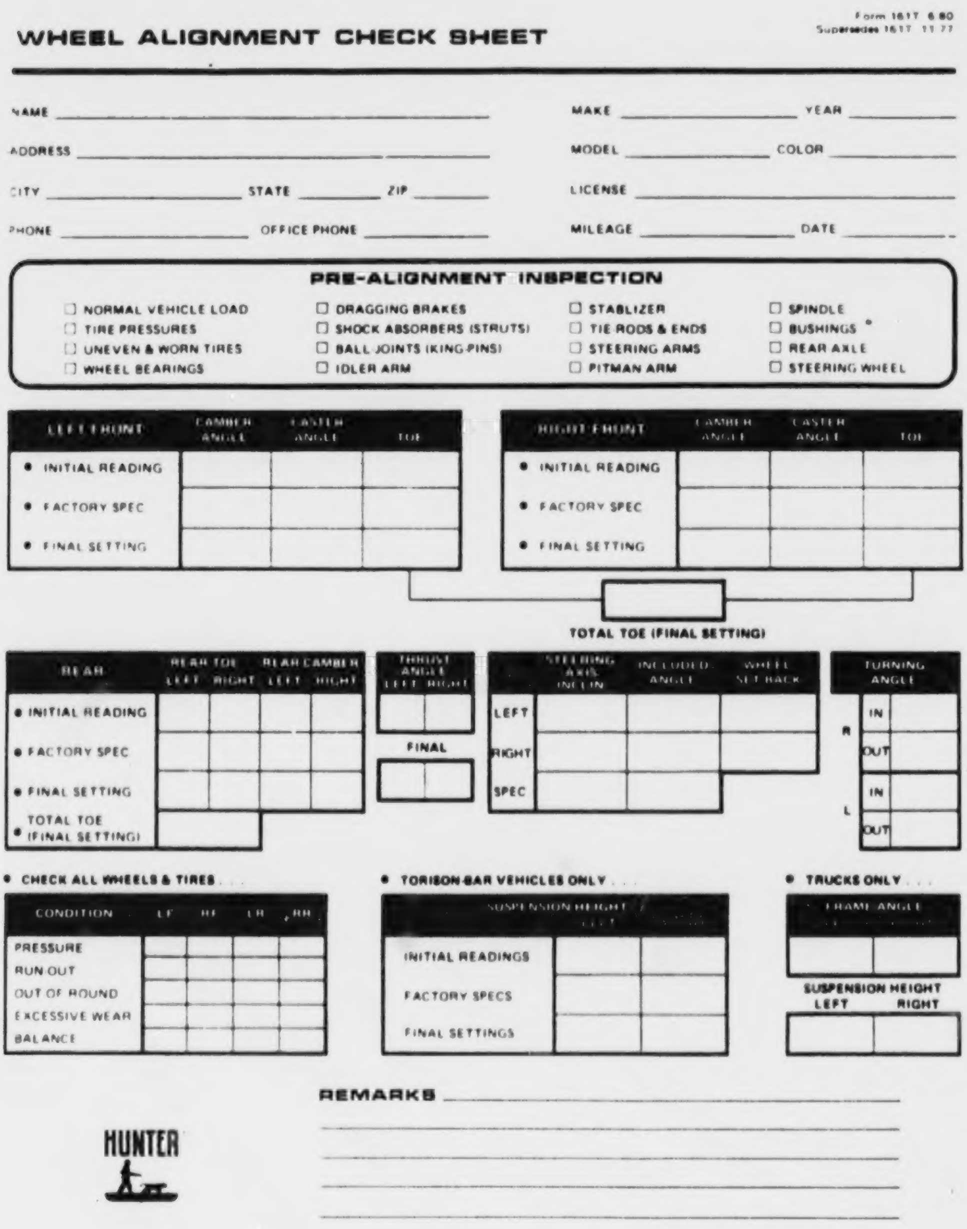
ACROSS

5. A type of bearing consisting of rollers or balls situated between two races, allowing the load to roll on balls or rollers thus minimizing friction
7. The installation of a cone-and-roller assembly with a light fit that can be installed with hand pressure
8. The part of a roller bearing that contains the cone (inside race), roller cage, and rollers; installed on a spindle with a push fit
9. An assembly that reduces friction between revolving and nonrevolving parts, allowing smooth movement of the parts

HANDOUT 2

SERVICE TAPERED ROLLER WHEEL BEARINGS

I



WHEEL ALIGNMENT CHECK SHEET

Form 1617 6-80
Supersedes 1617 11-77

NAME ______________________
ADDRESS ______________________
CITY ____________ STATE ________ ZIP ________
PHONE ____________ OFFICE PHONE ____________

MAKE ____________ YEAR ________
MODEL ____________ COLOR ________
LICENSE ______________________
MILEAGE ____________ DATE ________

PRE-ALIGNMENT INSPECTION

- ☐ NORMAL VEHICLE LOAD
- ☐ TIRE PRESSURES
- ☐ UNEVEN & WORN TIRES
- ☐ WHEEL BEARINGS
- ☐ DRAGGING BRAKES
- ☐ SHOCK ABSORBERS (STRUTS)
- ☐ BALL JOINTS (KING-PINS)
- ☐ IDLER ARM
- ☐ STABLIZER
- ☐ TIE RODS & ENDS
- ☐ STEERING ARMS
- ☐ PITMAN ARM
- ☐ SPINDLE
- ☐ BUSHINGS
- ☐ REAR AXLE
- ☐ STEERING WHEEL

LEFT FRONT	CAMBER ANGLE	CASTER ANGLE	TOE
● INITIAL READING			
● FACTORY SPEC			
● FINAL SETTING			

RIGHT FRONT	CAMBER ANGLE	CASTER ANGLE	TOE
● INITIAL READING			
● FACTORY SPEC			
● FINAL SETTING			

TOTAL TOE (FINAL SETTING)

REAR	REAR TOE		REAR CAMBER	
	LEFT	RIGHT	LEFT	RIGHT
● INITIAL READING				
● FACTORY SPEC				
● FINAL SETTING				
● TOTAL TOE (FINAL SETTING)				

THRUST ANGLE	
LEFT	RIGHT
FINAL	

	STEERING AXIS INCL'IN	INCLUDED ANGLE	WHEEL SET BACK
LEFT			
RIGHT			
SPEC			

TURNING ANGLE		
R	IN	
	OUT	
L	IN	
	OUT	

● CHECK ALL WHEELS & TIRES . . .

CONDITION	LF	RF	LR	RR
PRESSURE				
RUN OUT				
OUT OF ROUND				
EXCESSIVE WEAR				
BALANCE				

● TORISON-BAR VEHICLES ONLY . . .

SUSPENSION HEIGHT		
	LEFT	[illegible]
INITIAL READINGS		
FACTORY SPECS		
FINAL SETTINGS		

● TRUCKS ONLY . . .

FRAME ANGLE	

SUSPENSION HEIGHT	
LEFT	RIGHT

REMARKS ______________________

HUNTER

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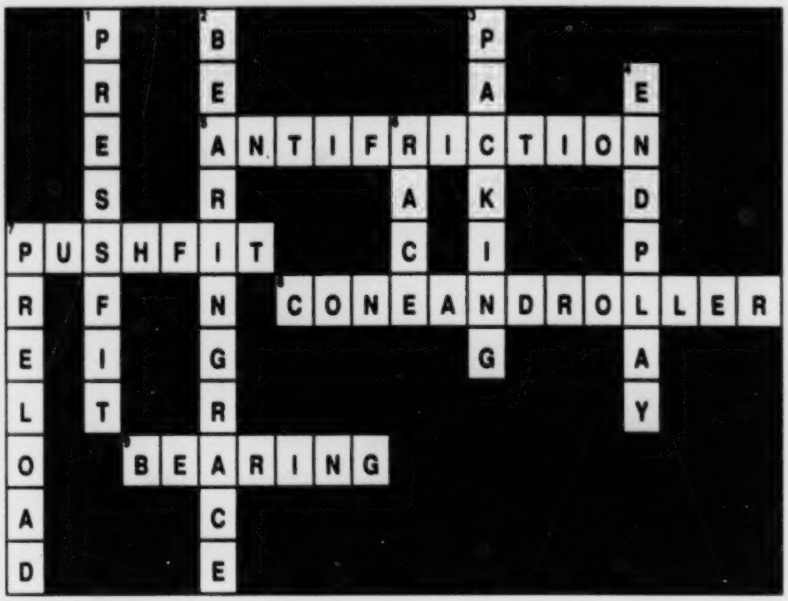
HANDOUT 1


1 PRESSFIT
2 BEARINGRACE
3 PACKING
4 ENDPLAY
5 ANTIFRICTION
6 RACE
7 PUSHFIT
7 PRELOAD
8 CONEANDROLLER
9 BEARING

PRETEST ANSWERS

SERVICE TAPERED ROLLER WHEEL BEARINGS

EVALUATOR

Use the following answer key to check student answers to pretest questions. To determine the students' individual study requirements from the pretest results, use the following table which shows the correlation between the objectives and the pretest questions. Then counsel the students individually on pretest results and study requirements.

TABLE

Correlations between objectives and pretest questions:

Objective	Question
1	1, 8, 10, 14, 26
2	6, 15
3	16, 17, 18
4	3, 29
5	4, 9, 19, 22, 25
6A	2, 5, 7, 11, 20, 23
6B	12, 13, 21, 24, 27, 28, 30

ANSWER KEY

1. C
2. B
3. B
4. D
5. D
6. C
7. A
8. C
9. C
10. B
11. C
12. D
13. B
14. A
15. D
16. D
17. B
18. B
19. C
20. D
21. C
22. A
23. D
24. B
25. A
26. D
27. A
28. C
29. D
30. B

PRETEST

SERVICE TAPERED ROLLER WHEEL BEARINGS

I

NAME ______________________ SCORE ________

DIRECTIONS

Read the following questions and problems, then put the letter of the item that best answers the question or solves the problem in the blank.

_____1. Which of the following is the best definition of *antifriction bearing*?

A. An assembly that increases friction between revolving and nonrevolving parts, allowing smooth movement of the parts
B. Part of a bearing assembly located on the outer side of the bearing cage
C. A bearing consisting of rollers or balls situated between two races, allowing the load to roll on balls or rollers thus minimizing friction
D. Nonadjustable sealed bearing assembly

_____2. Which of the following tools is used to measure end play in the hub assembly?

A. Torque-angle meter
B. Dial indicator
C. Micrometer
D. Feeler gauge

_____3. Which of the following is a desirable property of wheel bearing grease?

A. Is easily separated at high temperatures
B. Adheres to friction surfaces
C. Both A and B
D. Neither A nor B

______4. A customer explains that she recently had her vehicle in the shop and had the brake system repaired and the brake pads replaced. She notices, however, that her car still seems to pull to one side while driving. Which of the following could cause this problem?

A. Loose wheel bearings
B. Overtightened wheel bearings
C. Damaged wheel bearings
D. All of the above

______5. Technicians A and B are discussing wheel bearing adjustment. Technician A says that the basic procedure for adjusting wheel bearings is the same for both drive and non-drive wheels. Technician B says the procedures are the same except the bearings are torqued to different specifications. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______6. Technicians A and B are discussing wheel bearings. Technician A says the purpose of tapered roller wheel bearings is to reduce friction between the revolving wheel hub and the spindle. Technician B says their purpose is to spread vehicle loads over a larger surface area. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______7. Which of the following statements concerning wheel bearing adjustments is correct?

A. The wheel must never be removed
B. After being torqued to specifications, the spindle nut can be loosened slightly only to align it with cotter pin hole in the spindle
C. A cotter pin may be reused if it still retains 75 percent of its strength
D. Self-locking spindle nuts are installed in the same way as castellated nuts

______8. Which of the following is the best definition of *preload*?

A. Process of cleaning old grease from a bearing and then forcing new wheel bearing grease into the openings between the race and the ball or roller cage
B. Process of installing the cone-and-roller assembly on the hub
C. To adjust bearings so that they will work under mild pressure
D. To adjust the amount of axial movement in the hub due to the clearance in the bearings

______9. Of the following bearing problems, which does **not** necessarily require bearing replacement?

A. Etching
B. Misalignment
C. Stain discoloration
D. Galling

_____10. *Installation of a cone-and-roller assembly with a light fit requiring only hand pressure to install* defines which of the following terms?

A. Press fit
B. Push fit
C. Preload
D. Seating bearings

_____11. Technician A says loose wheel bearings can cause rapid tire wear. Technician B says they can cause uneven steering and vibrations when braking. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____12. Which of the following statements is **not** true?

A. Bearing assemblies should be cleaned and inspected before being repacked
B. The hub, races, and spindle should be cleaned before reinstalling bearings
C. Cleaned bearing assemblies should be inserted into their original positions on the hub and tested for roughness
D. A good bearing race does not need to be replaced if the cone-and-roller assembly is replaced

_____13. It is best to remove bearing races by:

A. Tapping a wooden dowel with a brass hammer
B. Tapping a brass drift with a hammer
C. Using a bearing race driver
D. Any of the above

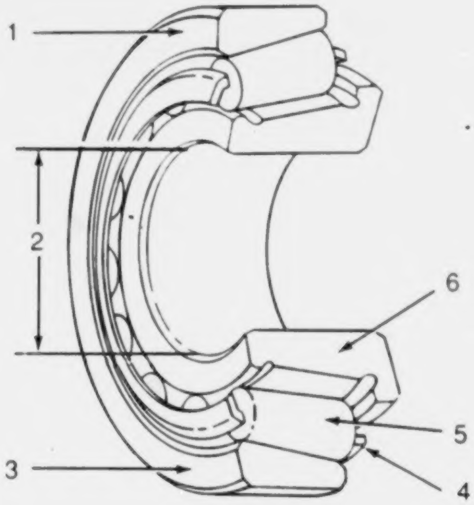
_____14. The definition *surface or path on which bearing balls or rollers move* best describes which of the following terms?

A. Race
B. Cage
C. Hub
D. None of the above

_____15. Which of the following statements describes the purpose of wheel bearings?

A. To control the amount of friction between a revolving wheel hub and the spindle
B. To spread vehicle loads over a larger surface area
C. To transfer steering action to the vehicle wheels
D. A and B

For questions 16 through 18 refer to the following illustration of a tapered roller wheel bearing:



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_____16. To which part is the arrow labeled 5 pointing?

A. Cone
B. Separator or cage
C. Cup
D. Tapered roller

_____17. The *cone* is indicated by the arrow labeled:

A. 1
B. 6
C. 5
D. 3

_____18. To which part is the arrow labeled 4 pointing?

A. Cone
B. Separator or cage
C. Cup
D. Tapered roller

_____19. Which of the following wheel bearing conditions can sometimes be corrected by only adjusting the bearings?

A. Worn wheel bearings
B. Misalignment
C. Loose wheel bearings
D. Both B and C

_____20. Which of the following statements concerning wheel bearing adjustments is correct?

A. End play should be measured before seating the bearings
B. The spindle nut is removed after end play is measured
C. Bearings are both seated and torqued to specifications in a single adjustment step
D. None of the above

_____21. When servicing wheel bearings, how is the inner cone-and-roller assembly removed?

A. By grasping with fingers and sliding it off the spindle
B. By using a bearing installation tool
C. By grasping with fingers and lifting it from the hub after the inner seal has been removed
D. It is permanently installed on the hub and is not removable

_____22. Technician A is servicing the wheel bearings on a customer's vehicle. Indentations are found on the race and roller surfaces. Technician A says the bearings must be replaced, but Technician B says they need to be replaced only if they are noisy. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____23. When are wheel bearings normally adjusted?

A. When the bearings are removed for routine cleaning, inspection, and packing
B. When brake or suspension work is being done, and the drum or disc brake rotor is removed
C. When the wheel is checked for axial movement
D. All of the above

_____24. Which of the following statements is correct?

A. A bearing packer must be used to pack or repack wheel bearings
B. Bearings can be packed or repacked by hand
C. After packing or repacking bearings, place them on a special greased surface on the floor if they will not be reinstalled immediately
D. Both B and C

_____25. Technicians A and B are discussing wheel bearing service. Technician A says damaged bearings should be replaced. Technician B disagrees, saying wheel bearings with some types of damage are still usable if repacked properly. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____26. Which of the following is the best definition of *push fit*?

A. The installation of a cup (outer race) with a tight or interference fit requiring more than hand pressure to install
B. The installation of a cup (outer race) with a light fit that can be installed with a special tool adapter
C. The installation of a cone-and-roller assembly with a tight or interference fit requiring more than hand pressure to install
D. The installation of a cone-and-roller assembly with a light fit requiring only hand pressure to install

_____27. Technicians A and B are discussing the procedure for cleaning, inspecting, and packing wheel bearings. Technician A says wheels should be marked so that they can be reinstalled in the same position. Technician B says the wheel covers do not have to be removed when repacking the bearings. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____28. Technician A says bearings from one hub should not be interchanged with those from another hub. Technician B says if either the bearing rollers or bearing race is defective, both must be replaced as a set. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____29. Which of the following is a property of wheel bearing grease?

A. Water-resistant
B. Heat-resistant
C. Noncorrosive
D. All of the above

_____30. Which of the following are guidelines to observe when cleaning, inspecting, and packing wheel bearings?

A. Replace only the cone-and-roller assembly if bearing rollers are defective
B. Always replace the grease seal
C. Use compressed air to spin clean bearing cone-and-roller assemblies
D. None of the above

INFORMATION SHEET

SERVICE TAPERED ROLLER WHEEL BEARINGS *I*

OBJECTIVE 1

Select the definitions of terms associated with wheel bearings.

antifriction bearing — A bearing consisting of rollers or balls situated between two races, allowing the load to roll on balls or rollers thus minimizing friction

NOTE: There are two main types of bearings used in automotive construction: friction and antifriction. Antifriction bearings are used for wheel bearings and are the bearings discussed in this unit.

bearing — An assembly that reduces friction between revolving and nonrevolving parts, allowing smooth movement of the parts

cone-and-roller assembly — The part of a roller bearing that contains the cone (inside race), cage, and rollers; installed on the spindle with a push fit

cup — The part of a bearing located on the outer side of the bearing rollers or balls and just inside the hub; installed in the hub with a press fit

end play — The amount of axial movement in a hub due to clearance in the bearings

packing — The process of cleaning old grease from the bearings and then forcing new wheel bearing grease into the openings between the races and the cage

preload — To adjust the bearings so that they will work under mild pressure

press fit — The installation of a cup (outer race) with a tight or interference fit requiring more than hand pressure to install

push fit — The installation of a cone-and-roller assembly with a light fit requiring only hand pressure to install

race — The surface or path on which bearing balls or rollers move

viscosity — A measure of how easily a liquid flows

WHEEL BEARINGS

Each wheel has both an inner and an outer bearing which are of different sizes. These bearings allow the wheel to turn freely over thousands of miles by reducing the friction between the wheel and the spindle. The grease used to lubricate the bearings can become contaminated even though the bearings are partially protected by the hub and brake drum or rotor. Contaminated grease can cause wheel bearings to become damaged, therefore, it is important to inspect, clean, and pack the wheel bearings each time they are removed, in addition to regular service recommended by the manufacturer. Improper wheel bearing adjustment or incorrectly installed or missing wheel bearing locking devices can cause severe bearing or hub damage.

NOTE: Some vehicles have wheel bearings which cannot be serviced.

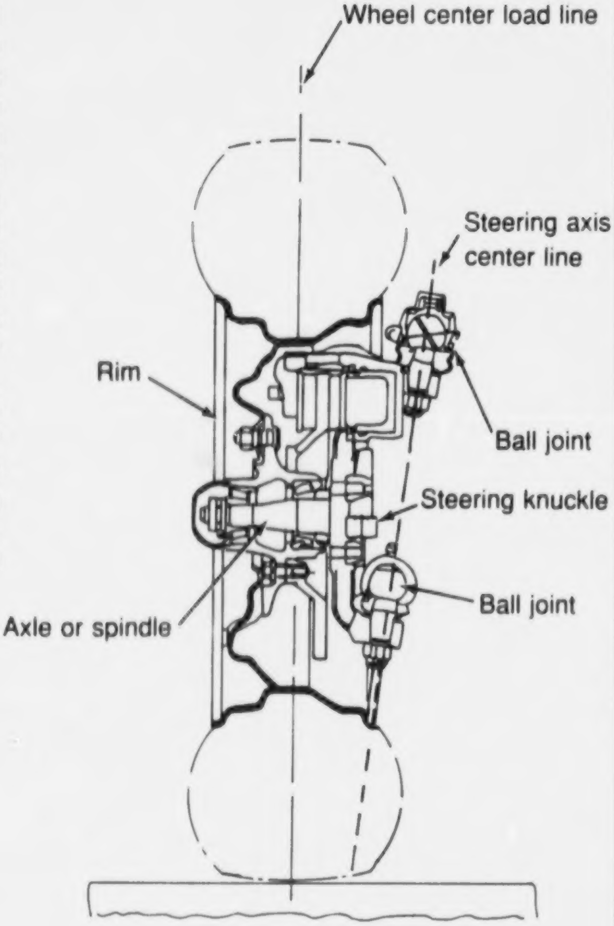
OBJECTIVE 2 **State the purposes of wheel bearings.**

- To reduce friction between the revolving wheel hub and the spindle
- To spread vehicle loads over a larger surface area

NOTE: The wheel bearings transmit the vehicle's radial (vertical) load and thrust, axial (side-to-side) load, to the road surface through the wheels.

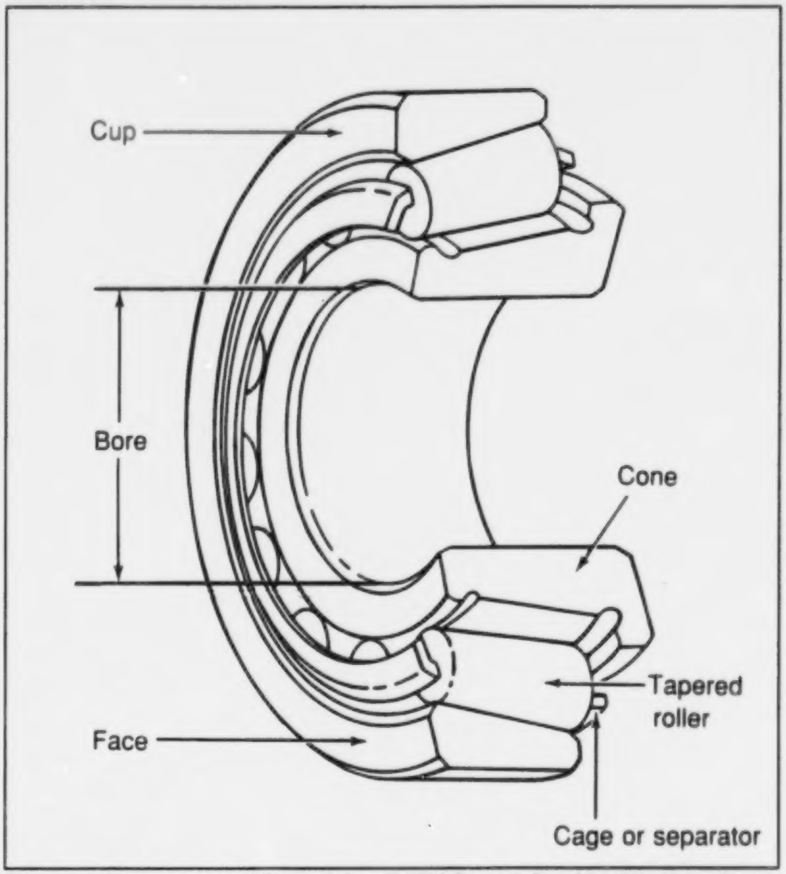
WHEEL BEARINGS AND LOAD LINES

Both the outer and inner wheel bearings support the weight of the vehicle. As shown in the figure at the right, the center load line of the wheel is almost in line with the inner wheel bearing. This design causes most of the weight to be carried on the largest (inner) wheel bearing, which is on the thickest portion of the spindle and nearest the pivot point of the spindle. This weight distribution reduces the chance of breaking the spindle. Since the wheel center load line intersects the road surface at nearly the same point as the steering axis centerline, the tire turns on nearly a single point of the road surface. This reduces the effort required to turn the wheel to a minimum.



OBJECTIVE 3 **Label the parts of a tapered roller wheel bearing assembly.**

FIGURE 1


Cup
Bore
Cone
Tapered roller
Face
Cage or separator

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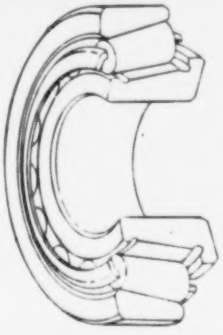
TYPES OF WHEEL BEARINGS

Although tapered roller wheel bearings are used on many vehicles, several other types are also used. Straight roller bearings are used on the rear wheels of some medium- and heavy-weight vehicles. Ball bearings are used on the rear wheels of some light vehicles. Another type of wheel bearing is the integrated ball bearing which is a permanently sealed bearing that cannot be serviced and is used primarily on front-wheel drive vehicles.

Tapered Roller Bearing



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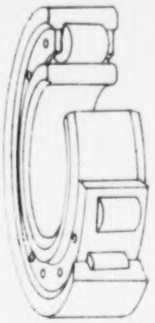
Straight Roller Bearing



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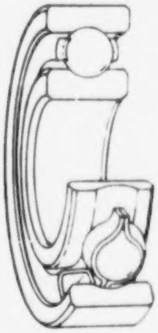
Ball Bearing



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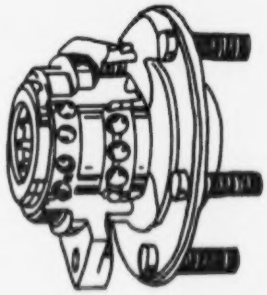
Integrated Ball Bearing



Courtesy of General Motors of Canada, Limited.

The basic bearing assembly is similar for each bearing type, but there are some differences. One difference is the shape of the roller in roller bearings, which can be straight or tapered. In some types of bearings, ball bearings are used instead of roller bearings. The integrated bearing differs in that the inner bearing races are combined with the spindle and the outer bearing races are part of the hub/flange.

OBJECTIVE 4

List the properties of wheel bearing grease.

- Water-resistant
- Heat-resistant, will not change viscosity as the temperature rises
- Stable at all temperatures, will not separate as the temperature changes
- Noncorrosive
- Adheres to smooth surfaces
- Will not form acids under adverse conditions

WHEEL BEARING LUBRICATION

Some rear wheel bearings are automatically lubricated by oil from the differential; however, some require separate lubrication. Others are sealed and cannot be serviced. The vehicle manufacturer supplies lubrication charts which should be followed both as to type and frequency of lubrication. Front wheel bearings require special wheel bearing grease. This is a short-fiber grease with a high melting point. The high melting point is critical because the brake drums surrounding the wheel bearings get hot, sometimes up to 700°F. Not all this heat is applied to the wheel bearings, but a considerable amount is absorbed by the hubs. If the grease melts, it can leak past the oil seal and ruin the brake linings—not to mention causing bearing damage due to loss of lubrication.

CAUTION
Wheel bearings must always be packed before they are installed in the hub. Failure to comply can result in insufficient bearing lubrication and could cause bearing failure.

WHEEL BEARING PROBLEMS

Although servicing wheel bearings is not usually complicated, identifying wheel bearing problems can be difficult. This is because symptoms caused by wheel bearing problems can be the same as those caused by other systems. For example, uneven braking can be caused by loose wheel bearings, but it can also be caused by worn brake pads or a warped brake rotor. Pulling to one side can be caused by damaged wheel bearings; however, it can also be caused by incorrect alignment or a low front tire.

An important part of diagnosing wheel bearing problems is test driving the vehicle. The technician must pay close attention to how the vehicle handles and must listen carefully for any noises, noting how and under what circumstances noises change or stop.

On rear-wheel drive vehicles, loose or rough front wheel bearings produce a noise that can be confused with rear axle noise. The difference is front wheel bearing noise does not change when the vehicle is coasting or accelerating. A light application of the brake while holding the vehicle's speed constant often causes wheel bearing noise to diminish, because this action reduces some of the weight supported by the bearings. In the shop, front wheel bearings can be checked easily for noise by raising the suspected wheel and spinning it. If the vehicle is equipped with disc brakes, the brake pads must be disengaged from the rotor before making this check.

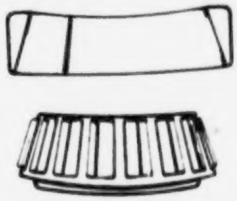
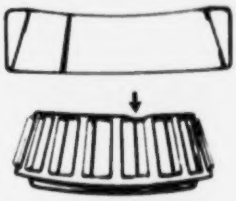
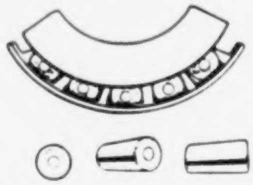
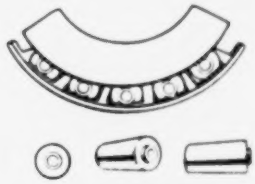
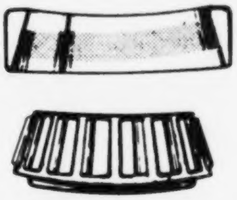
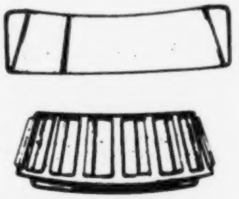
During a road test, the bearings can be checked by moving the steering wheel to the right and left while listening for noise. Turning to the left places an axial load on the right outer bearing and the left inner bearing. Turning to the right places an axial load on the left outer bearing and the right inner bearing. If any of these bearings are defective, a noticeable noise will be heard.

Listed on the following page are driving problems that can result from defective or improperly installed wheel bearings. Problems that result from defective wheel bearings can be solved only by replacing the bearing. Those caused by improper installation must be corrected. Often improper installations will lead to bearing damage and the bearing must be replaced.

Many of the driving problems listed can be caused by other conditions such as worn suspension parts or defective brakes. It is a good idea for the service technician to become familiar with the indications of brake and suspension problems. Use the information in this supplement as another clue in analyzing problem situations.

Loose wheel bearings can cause:	• Noise—scraping noise during turn; clunk as wheel begins turn • Vehicle to pull to one side • Chatter • Uneven braking • Shimmy • Too much play in the steering system
Overtightened wheel bearings can cause:	• Noise—groan, squeak, or squeal • Uneven braking • Overheating of the wheel and bearing • Vehicle to pull to one side
Damaged wheel bearings can cause:	• Noise—growl, click, rattle • Shimmy in affected wheel • Vehicle to pull to one side • Chatter • Grab (brakes applied)
Worn wheel bearings can cause:	• Noise—groan, growl, click, rattle, or squeak (brakes not applied) • Grab (brakes applied) • The same indications as a loose bearing (see above)
Dry wheel bearings can cause:	• Noise—groan, growl, click, squeak, or squeal (brakes not applied) • Chatter • Grab (brakes applied)

TAPERED ROLLER BEARING DAMAGE DIAGNOSIS CHART

 **Good bearing**	 **Bent cage** Cage damage due to improper handling or tool usage. Replace bearing.
 **Galling** Metal smears on roller ends due to overheat, lubricant failure, or overload. Replace bearing—check seals and check for proper lubrication.	 **Abrasive step wear** Pattern on roller ends caused by fine abrasives. Clean all parts and housings, check seals and bearings, and replace if leaking, rough, or noisy.
 **Misalignment** Outer race misalignment due to foreign object. Clean related parts and replace bearing. Make sure races are properly seated.	 **Indentations** Surface depressions on race and rollers caused by hard particles of foreign material. Clean all parts and housings, check seals, and replace bearings if rough or noisy.

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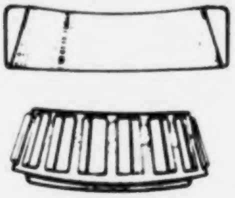
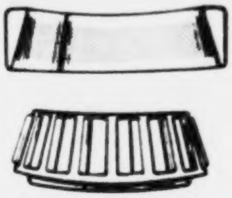
TAPERED ROLLER BEARING DAMAGE DIAGNOSIS CHART (CONTINUED)



Cage wear

Wear around outside diameter of cage and roller pockets caused by abrasive material and inefficient lubrication.

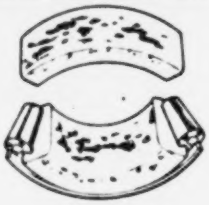
Check seals and replace bearings.



Abrasive roller wear

Pattern on races and rollers caused by fine abrasives.

Clean all parts and housings, check seals and bearings, and replace if leaking, rough, or noisy.

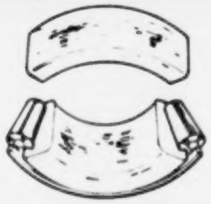


Smears

Smearing of metal due to slippage. Slippage can be caused by poor fits, lubrication, overheating, overloads, or handling damage.

Replace bearings, clean related parts, and check for proper fit and lubrication.

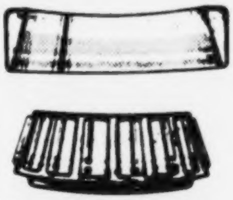
Replace shaft if damaged.



Frettage

Corrosion set up by small relative movement of parts with no lubrication.

Replace bearing, clean related parts, check seals, and check for proper lubrication.

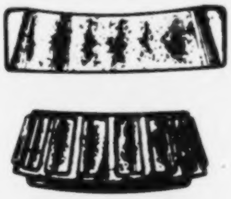


Stain discoloration

Discoloration can range from light brown to black caused by incorrect lubricant or moisture.

Reuse bearings if stains can be removed by light polishing or if no evidence of overheating is observed.

Check seals and related parts for damage.



Fatigue spalling

Flaking of ressions on race and rollers caused by hard particles of foreign material.

Clean all parts and housings, check seals, and replace bearings if rough or noisy.

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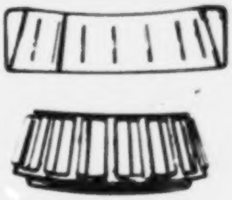
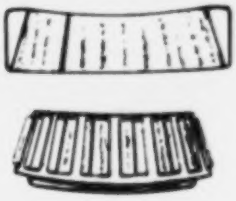
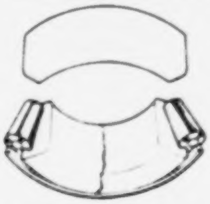
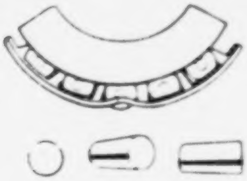
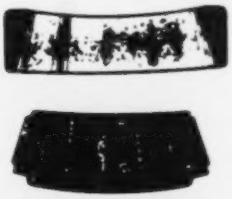
TAPERED ROLLER BEARING DAMAGE DIAGNOSIS CHART (CONTINUED)

 **Brinelling** Surface indentations in raceway caused by rollers either under impact loading or vibration while the bearing is not rotating. Replace bearing if rough or noisy.	 **Etching** Bearing surfaces appear gray or grayish-black in color with related etching away of material usually at roller spacing. Replace bearings—check seals and check for proper lubrication.
 **Cracked inner race** Race cracked due to improper fit, cocking, or poor bearing seats.	 **Bent cage** Cage damage due to improper handling or tool usage. Replace bearing.
 **Heat discoloration** Heat discoloration can range from faint yellow to dark blue resulting from overload or incorrect lubricant.	Excessive heat can cause softening of races or rollers. To check for loss of temper on races or rollers a simple file test may be made. A file drawn over a tempered part will grab and cut metal, whereas, a file drawn over a hard part will glide readily with no metal cutting. Replace bearings if overheating damage is indicated. Check seals and other parts.

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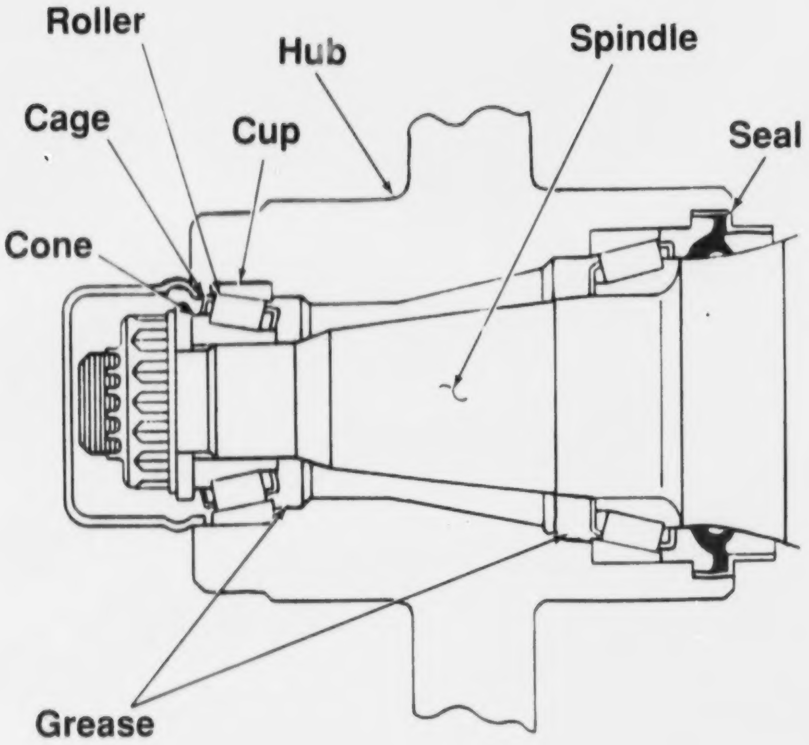
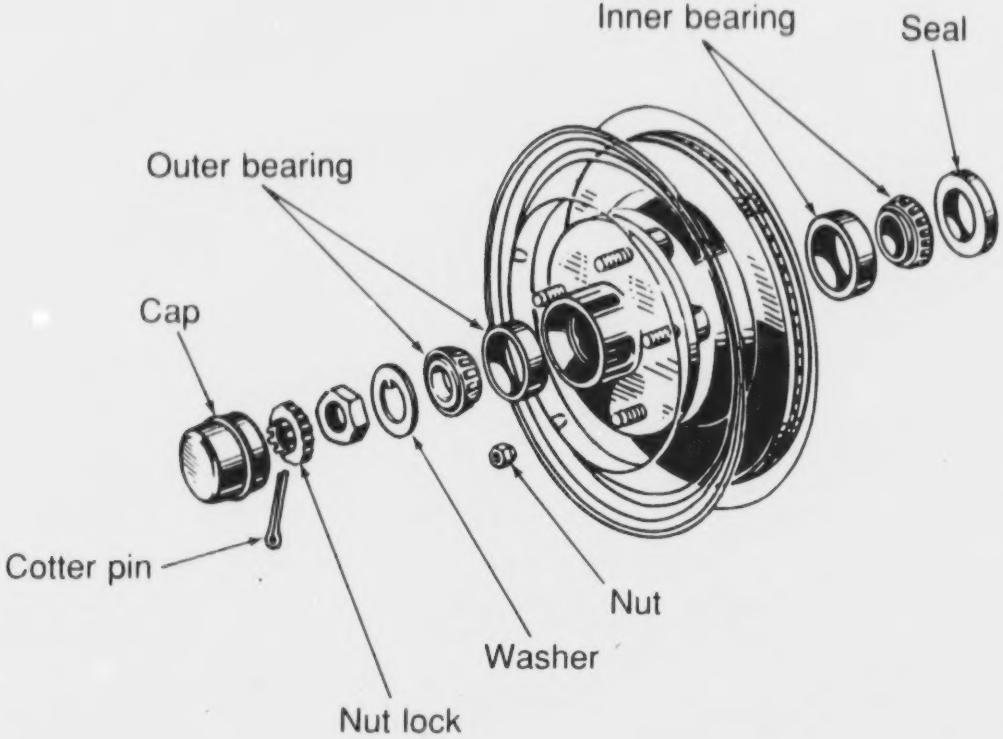
Roller Wheel Bearing Assembly


Roller
Hub
Spindle
Cage
Cup
Seal
Cone
Grease

Used with permission of Chrysler Corp

Hub Assembly—Rear Wheel Drive

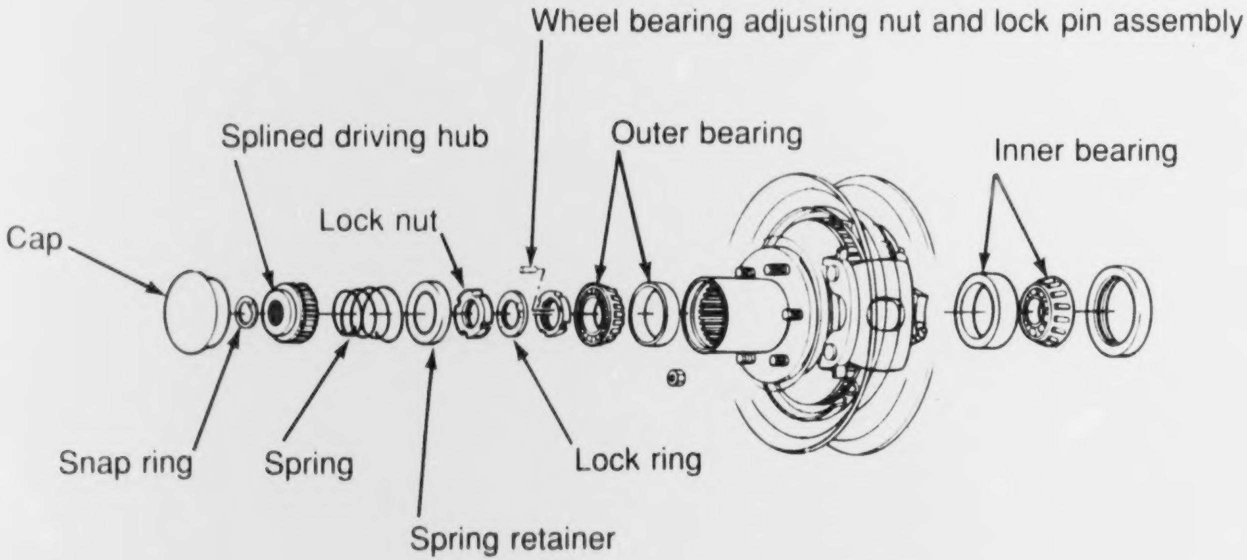

Inner bearing
Seal
Outer bearing
Cap
Cotter pin
Nut
Washer
Nut lock

TRANSPARENCY MASTER 2 - SS
1 - 43

Used with permission of Ford Motor Co

TM 2

Hub Assembly—Front Wheel Drive


Wheel bearing adjusting nut and lock pin assembly
Splined driving hub
Outer bearing
Inner bearing
Lock nut
Cap
Snap ring
Spring
Lock ring
Spring retainer

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ACTIVITY SHEET 1

SERVICE TAPERED ROLLER WHEEL BEARINGS

NAME ______________________ SCORE ______

ANSWER GENERAL QUESTIONS ABOUT TAPERED ROLLER WHEEL BEARINGS

INTRODUCTION

To become certified as a Steering and Suspension Technician, you must pass a test on steering and suspension systems compiled by the National Institute for Automotive Service Excellence (ASE). The certification test covers all aspects of automotive steering and suspension systems. This activity sheet contains questions on tapered roller wheel bearings similar in content and style to those found on the actual ASE certification test.

DIRECTIONS

Read each of the following study questions twice. The second time you may notice a key word that you overlooked the first time. Every word in a question is important and can provide a clue to the right answer. Select the answer that is **most** correct. Write the correct letters in the answer blanks.

After you have completed this activity sheet, get together with a group of your classmates and use the answer key to check your answers. Discuss the questions and their answers, paying particular attention to those that were answered incorrectly. Review any information that you do not understand.

______1. The outer bearing cup is spinning in the front hub. What parts should be replaced?

A. Cup and bearing
B. Cup only
C. Hub only
D. Cup, bearing, and hub

______2. You are replacing a left front outer wheel bearing that has failed for the third time in a month. What could be the possible cause?

A. Incompatible wheel bearing grease
B. Worn cup
C. Either A or B
D. Neither A nor B

______3. Technician A says the procedure for adjusting wheel bearings is the same for both drive wheels and non-drive wheels. Technician B says the adjustment procedure is the same except for the torque specifications. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

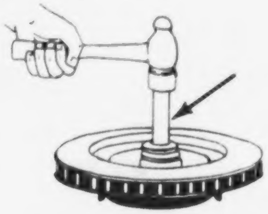
______4. On what type of vehicles are integrated ball bearings primarily used?

A. Medium-weight and heavy-weight vehicles
B. Rear-wheel drive vehicles
C. Smaller, light vehicles
D. Front-wheel drive vehicles

______5. After bearings are removed from the hub, they should be:

A. Cleaned with gasoline, rinsed with water, and dried thoroughly using compressed air and a low-pressure nozzle
B. Cleaned by spinning the bearings with compressed air
C. Cleaned by wiping off excess grease, soaking in cleaning solvent, scrubbing, and drying thoroughly using compressed air and a low-pressure nozzle
D. Cleaned by soaking in a manufacturer-recommended cleaning solvent and dried by spinning the bearings with compressed air

______6. What is the name of the tool indicated by the arrow in the illustration below?



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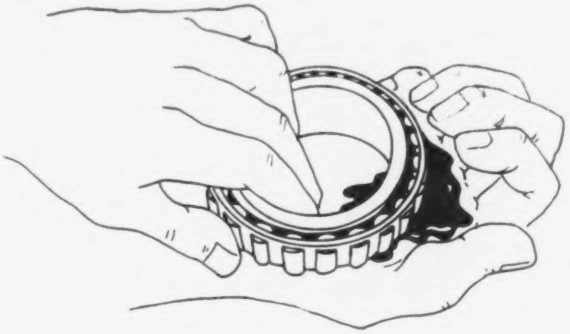
A. Seal driver
B. Bearing cone driver
C. Bearing cone remover
D. Cone-and-roller installation tool

______7. What is the technician doing in the illustration below?



From *Automotive Brake Service, Unit 2*, © 1981 by State of Florida Department of State. Used with permission of Florida Department of State.

A. Cleaning wheel bearings
B. Packing wheel bearings
C. Removing rollers
D. Repairing a cone-and-roller assembly

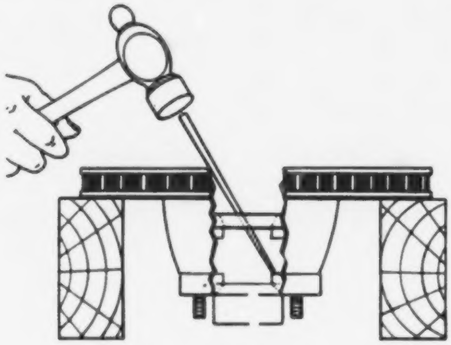
______8. What is the purpose of indexing wheels before removing them?

- A. So the wheel can be reinstalled on the correct hub
- B. So the tire can be properly reinstalled on the correct rim
- C. So the same lug nuts can be used on the same bolts
- D. So the wheel can be reinstalled on its hub and maintain wheel balance

______9. Which of the following tools can be used to remove the dust cap?

- A. Diagonal-cutting pliers
- B. Dust cap removing tool
- C. Channel-lock pliers
- D. Either B or C

_____10. What is the technician doing in the illustration below?



From *Automotive Brake Service, Unit 2*. © 1981 by State of Florida Department of State. Used with permission of Florida Department of State.

- A. Removing the rotor
- B. Removing the inner wheel bearing race
- C. Adjusting the wheel bearing
- D. Torquing lug nuts

_____11. A cotter pin is used to complete the installation of what type of nut?

A. Castellated nut
B. Self-locking nut
C. Both A and B
D. Neither A nor B

ACTIVITY ANSWERS

SERVICE TAPERED ROLLER WHEEL BEARINGS

ACTIVITY SHEET 1

1. D
2. A
3. D
4. D
5. C
6. A
7. B
8. D
9. D
10. B
11. A

ASSIGNMENT SHEET 1

SERVICE TAPERED ROLLER WHEEL BEARINGS

I

NAME ______________________ SCORE ________

OBJECTIVE 5

Diagnose wheel bearing problems.

INTRODUCTION

When attempting to diagnose wheel bearing problems, service technicians must develop the ability to identify the problem, determine the probable cause, and take all actions necessary to correct the problem. Failure to correctly diagnose a problem could result in damage to steering components.

Problems and situations that could indicate wheel bearing trouble are listed below. Many of these problems can also be caused by other conditions such as worn suspension parts or defective brakes. For this assignment, **assume that these problems indicate wheel bearing trouble.**

DIRECTIONS PART A

Refer to Student Supplements 1 and 2 to determine possible causes and the corrective actions needed.

1. **Problem**—A squealing or grinding noise can be heard when driving the vehicle around corners.

   Probable cause(s) — ______________________

   ____

   ____

   Corrective action(s) — ______________________

   ____

   ____

2. **Problem**—You have removed the wheel bearings and discover that the roller ends contain galling (metal smears).

   Probable cause(s) — ____________________

   ____

   ____

   Corrective action(s) — ____________________

   ____

   ____

3. **Problem**—When servicing the wheel bearings, you notice that the outside diameter of the cage shows wear.

   Probable cause(s) — ____________________

   ____

   ____

   Corrective action(s) — ____________________

   ____

   ____

4. **Problem**—Upon inspection of a cone-and-roller assembly, you discover a cracked inner race.

   Probable cause(s) — ____________________

   ____

   ____

   Corrective action(s) — ____________________

   ____

   ____

5. **Problem**—You are inspecting a wheel bearing and discover frettage (corrosion) on the race.

Probable cause(s) — ________________________________

____

____

Corrective action(s) — ______________________________

____

____

DIRECTIONS PART B

Read the following problems and situations and select the answer that is **most** correct. Write the correct letters in the blanks.

______1. Technician A says overtightened wheel bearings can cause uneven braking. Technician B says uneven braking can be caused by wheel bearings that are loose. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______2. A customer explains that he recently had his vehicle in the shop and had the brake system inspected and brake pads replaced, but he complains that his vehicle still pulls to one side. Which of the following could cause this problem?

A. Loose wheel bearings
B. Overtightened wheel bearings
C. Damaged wheel bearings
D. All of the above

______3. Too much play in the steering system can be caused by which of the following?

A. Overtightened wheel bearings
B. Damaged wheel bearings
C. Worn wheel bearings
D. None of the above

______4. While servicing the wheel bearings on a customer's vehicle, stain discoloration is found on one bearing. Technician A says the bearing must be replaced. Technician B says the bearing can be reused if the stains can be removed by light polishing. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______5. A customer brings her vehicle to your shop, and she says she can hear a scraping noise when turning the vehicle. She also says the front brake pads were replaced less than a month ago. What condition could cause this scraping noise?

A. Cracked cone
B. Damaged cup
C. Loose wheel bearings
D. Overtightened wheel bearings

______6. Which of the following wheel bearing problems can cause chatter?

A. Dry wheel bearings
B. Etching on bearing surfaces
C. Frettage
D. Overtightened wheel bearings

ASSIGNMENT ANSWERS

SERVICE TAPERED ROLLER WHEEL BEARINGS

ASSIGNMENT SHEET 1

PART A

1. Probable cause(s) — Worn, damaged, or improperly tightened wheel bearings
   Corrective action(s) — Inspect wheel bearings, replace if defective, pack, and adjust to specified torque

2. Probable cause(s) — Overheating, lubricant failure, overload
   Corrective action(s) — Replace, pack, and adjust bearings

3. Probable cause(s) — Contamination, improper adjustment
   Corrective action(s) — Replace, pack, and adjust bearings

4. Probable cause(s) — Improper fit, cocking, poor bearing seats, overtightening
   Corrective action(s) — Replace, pack, and adjust bearings

5. Probable cause(s) — Inadequate lubrication
   Corrective action(s) — Replace, pack, and adjust bearings

PART B

1. C
2. D
3. D
4. B
5. C
6. A

JOB
SHEET 1

SERVICE TAPERED ROLLER WHEEL BEARINGS

I

OBJECTIVE 6A

Adjust wheel bearings.

INTRODUCTION

Adjusting the wheel bearings is an important part of steering system service. If wheel bearings are loose or excessively tight, they can overheat or wear improperly and become damaged. Loose wheel bearings can also cause rapid tire wear, uneven steering, and vibrations when braking.

Wheel bearings are normally adjusted when any of the following occurs:

- The wheel is checked for axial movement
- The bearings are removed for routine cleaning, inspection, and packing (approximately every 24,000 miles)
- Brake or suspension work is being done, and the drum or disc brake rotor must be removed as part of the work

Adjusting wheel bearings is not complicated. Although the basic adjustment procedure is the same for most vehicles, there are a few exceptions. For instance, procedures vary for wheels with self-locking spindle nuts and for vehicles which require the use of a torque-angle meter to torque the bearings.

This job sheet outlines the procedure for adjusting wheel bearings on the *non-drive* wheels of vehicles without self-locking nuts. The procedures and tools used for the actual wheel-bearing adjustment vary, so always follow the vehicle manufacturer's instructions and specifications when adjusting wheel bearings. Improper adjustment can cause damage to the bearings and tires as well as poor vehicle handling and braking vibrations.

EQUIPMENT AND MATERIALS

- Vehicle
- Appropriate service manual
- Eye protection
- Hydraulic lift or hoist stand
- Rubber mallet
- Replacement cotter pins
- Approved cleaning solvent
- Diagonal-cutting pliers
- Wheel cover removing tool
- Dust cap removing tool or channel-lock pliers

- Torque wrench
- Torque-angle meter, if specified by vehicle manufacturer

CAUTION
Always check the procedure in the vehicle's service manual before beginning any service or repair.

PROCEDURE

Adjust a wheel bearing

CAUTION

Loose wheel bearings should be removed, cleaned, and inspected for wear and damage, not simply adjusted. Acceptable bearings can be packed and reused. Failure to comply can result in wheel bearing failure.

1. Raise vehicle and support safely.

2. Remove the wheel cover.

   CAUTION

   When removing the left front dust cap, use care to avoid damage to the speedometer drive connection on some vehicles. Failure to comply can cause damage to the speedometer cable.

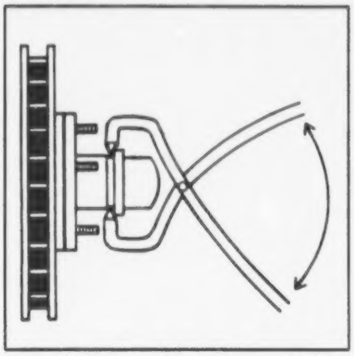
3. Remove the dust cap from the hub, using either a dust cap removing tool or channel-lock pliers.

   CAUTION

   When removing a dust cap, it is important to avoid bending or denting the cap with the removal tool. A bent or severely dented cap may not seal properly, thus allowing moisture and dirt to enter the hub and damage the wheel bearings.

4. If a dust cap removing tool is used, rock the dust cap back and forth until the cap comes off the hub. (Figure 1)

FIGURE 1



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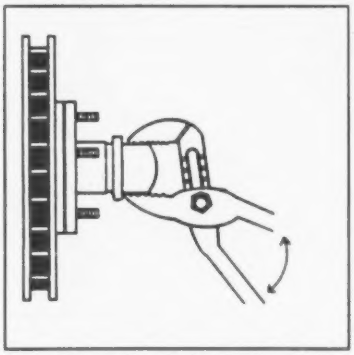
5. If a dust cap removing tool is not available, carefully remove the dust cap with channel-lock pliers. (Figure 2) Grip the dust cap tightly with the pliers, then rock the cap up and down until the cap comes off.

FIGURE 2



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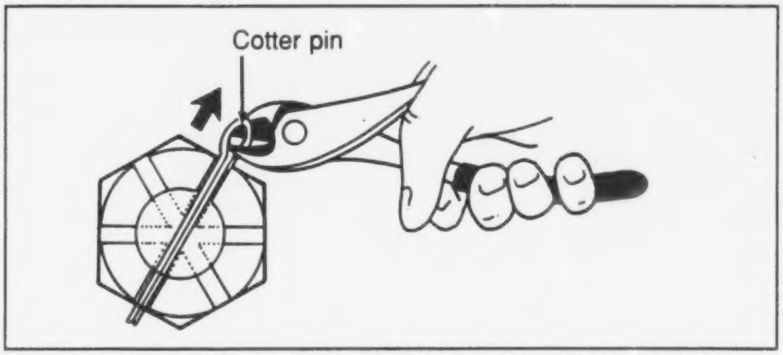
6. If the vehicle is equipped with a spindle nut cotter pin, use diagonal-cutting pliers to straighten the ends of the cotter pin.

7. Use the pliers to grasp the head of the cotter pin and pull it out of the hole in the spindle nut, prying with the pliers against the nut. (Figure 3) Discard the cotter pin.

FIGURE 3



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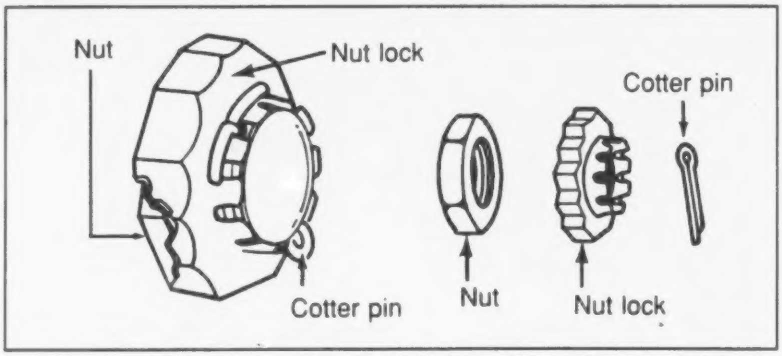
8. Remove the nut lock if the vehicle is so equipped. (Figure 4)

   NOTE: Some vehicles use a locking device called a *nut lock*, which makes it possible to install the cotter pin without moving the spindle nut. The nut lock can be tried in various positions until a position is found which allows the cotter pin to be inserted.

FIGURE 4



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9. Tighten the spindle nut to the specified torque while rotating the wheel forward by hand to seat the bearing.

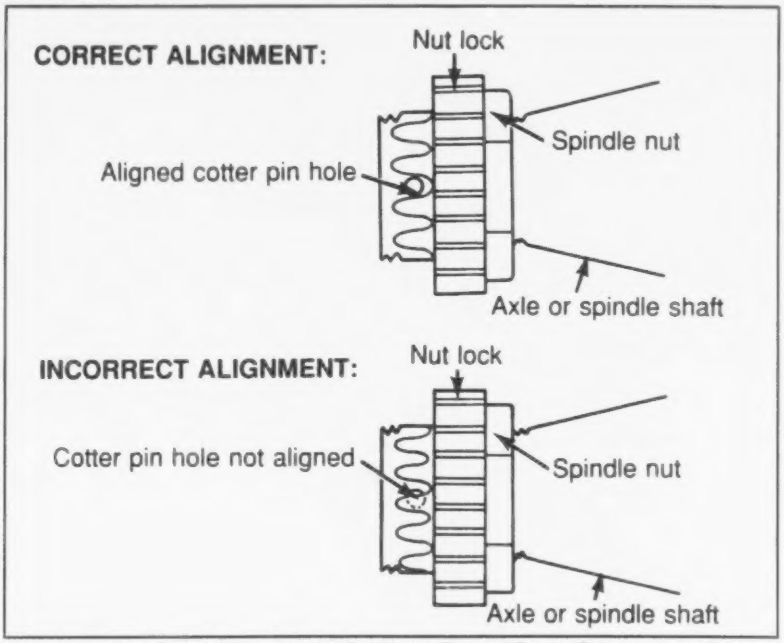
NOTE: In addition to seating the bearing, rotating the wheel by hand will allow you to locate and remove any grease or burrs that could cause wheel bearing play later. Some manufacturers call for finger-tightening the spindle nut at this point instead of using a torque wrench. Others call for the use of a torque-angle meter.

CAUTION

If a nut lock is used, do not move the spindle nut to align the nut lock with the spindle hole. Moving the spindle nut can make the final adjustment either too loose or too tight. Once the spindle nut has been torqued to final specifications, it is important not to move it. Failure to comply could cause wheel bearing damage.

10. Install the nut lock, aligning one of the slots in the top of the nut lock with the cotter pin hole in the spindle. (Figure 5)

FIGURE 5


CORRECT ALIGNMENT:
Nut lock
Spindle nut
Aligned cotter pin hole
Axle or spindle shaft
INCORRECT ALIGNMENT:
Nut lock
Cotter pin hole not aligned
Spindle nut
Axle or spindle shaft

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11. If a castellated nut is used, and a nut cotter pin slot is not properly aligned with the spindle hole, slightly loosen the nut until it is properly aligned with the hole.

CAUTION

Always install a new cotter pin. Never reuse an old cotter pin, because it has been weakened during removal and is unsafe. Failure to comply could cause a wheel to come loose.

12. Insert the cotter pin through the nut lock or castellated nut and through the hole in the spindle.

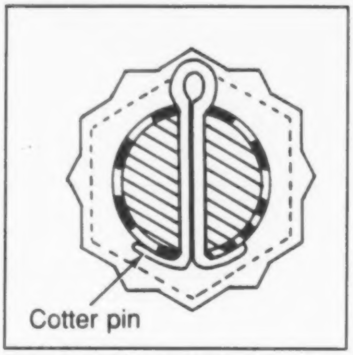
13. Using diagonal-cutting pliers, bend the ends of the cotter pin in opposite directions to secure it.

14. Cut off the extra length to ensure that the ends will not interfere with the dust cap. (Figure 6)

◆ WARNING ◆

Always wear eye protection when cutting a cotter pin with diagonal cutters. Failure to comply could cause eye damage from flying cotter pin ends.

FIGURE 6



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15. Clean the dust cap with an approved cleaning solvent and wipe it dry.

16. Center the dust cap on the hub and use a rubber mallet to tap it onto the hub.

17. Replace the wheel and wheel cover.

18. Lower the vehicle.

19. Torque the lug nuts to manufacturers specifications.

20. Road test the vehicle, making tight left and right turns and listening for any unusual noises.

CAUTION

Before test driving any vehicle, check the fluid level in the master cylinder and depress the brake pedal to verify that there is adequate pedal reserve. Make a series of low-speed stops to verify that the brakes are safe for road testing.

21. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 2

SERVICE TAPERED ROLLER WHEEL BEARINGS

OBJECTIVE 6B

Remove, clean, inspect, pack and install non-drive wheel bearings and replace seals.

INTRODUCTION

Lack of lubrication is the most common cause of wheel bearing failure. Regular servicing can help ensure that wheel bearings stay in good condition. Most vehicle manufacturers recommend that bearings be serviced and lubricated at intervals of 25,000 to 30,000 miles.

This job sheet outlines the basic procedure for removing, cleaning, inspecting, replacing, and packing wheel bearings. Some procedures vary for different vehicles, so refer to a vehicle service manual covering the exact make, model, and year of vehicle for variations. There are some general guidelines that apply when performing this procedure on any vehicle, and these are listed below.

Guidelines:

- Procedures for removing bearings from drive and non-drive wheels are different.
- Make sure that the bearings from one hub do not become interchanged with those of another.
- Replace the entire bearing if bearing rollers or races are defective. Since each cone-and-roller assembly sets up a wear pattern in its race, the assembly and race are a matched set.
- Never use compressed air to spin clean bearing cone-and-roller assemblies since this could cause the assemblies to fly apart.
- Always replace the grease seal with a new seal. A defective grease seal will not seal properly and can allow the grease to become contaminated from road dirt and moisture.
- Refer to a vehicle service manual for torque specifications, recommended wheel bearing grease, and exact bearing adjustment procedures.

EQUIPMENT AND MATERIALS

- Vehicle
- Appropriate service manual
- Eye protection

- Wheel cover removing tool
- C-clamp
- Hydraulic lift or hoist stand
- Screw driver
- Approved asbestos safety equipment and recommended protective clothing
- Fender and seat covers
- Mechanic's wire
- Steel hammer
- Syringe
- Low-pressure air nozzle
- Dust cap removing tool
- Seal driver
- Dial indicator
- Torque wrench
- Bearing driver
- Seal driver
- Wooden dowel
- Wheel bearing packer and instructors for packer
- Brass drift
- Clean shop towels
- Parts cleaning brush
- Wood blocks
- Appropriate wheel bearing grease
- Approved cleaning solvent
- Approved brake fluid
- Replacement grease seals
- Diagonal-cutting pliers
- Chalk or permanent marker
- Rubber-tipped hammer
- Rubber mallet
- Brake adjusting spoon
- Combination wrench
- Pry bar
- Replacement parts as necessary
- Light oil

◆ WARNING ◆

Many brake components contain asbestos fibers. Breathing asbestos dust is *very* harmful to your health. Asbestos fibers can irritate the lungs and cause asbestosis and cancer. Use approved safety equipment and wear recommended protective clothing when working with these brake components. Strictly follow all asbestos safety rules!

CAUTION
Always check the procedure in the vehicle's service manual before beginning any service or repair.

PROCEDURE

Prepare the vehicle for wheel bearing service

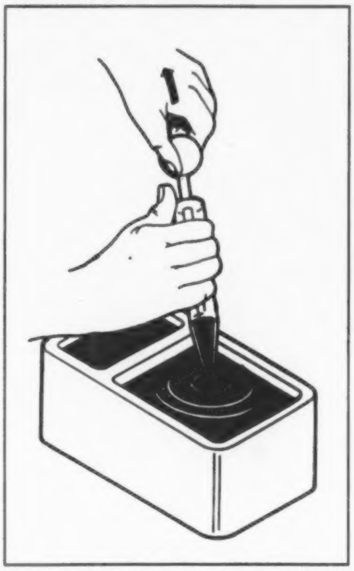
1. Cover fenders and seats.

CAUTION

Be careful **not** to spill brake fluid on any chrome or painted surfaces, as it may damage these finishes. Brake fluid is poisonous; avoid contact with skin and do *not* allow fluid to get into eyes. Keep brake fluid away from fire; brake fluid is flammable.

2. If a wheel with disc brakes is to be serviced, use a syringe to remove about two-thirds of the brake fluid from the master cylinder reservoir supplying the wheel. (Figure 1)

FIGURE 1



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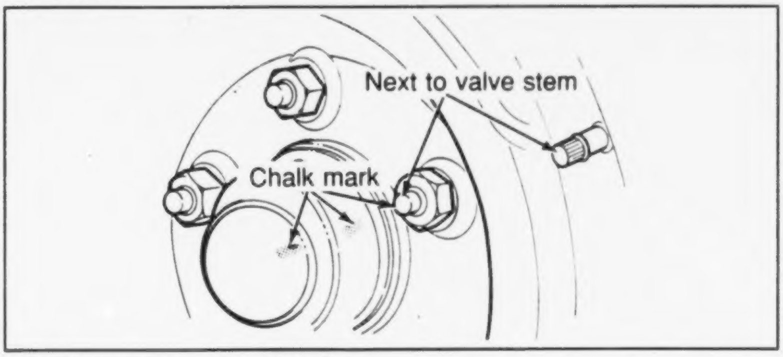
3. Remove the wheel cover and loosen the lug nuts or bolts slightly on all wheels to be serviced.

4. Raise the vehicle and support safely.

5. Mark each wheel to be removed with chalk or permanent marker as shown. (Figure 2)

   NOTE: Marking the wheels is necessary to ensure that the wheels that have been balanced in conjunction with their hubs are reinstalled in the original position on the hub.

FIGURE 2



Used with permission of Ford Motor Co.

6. Remove the lug nuts and the wheel.

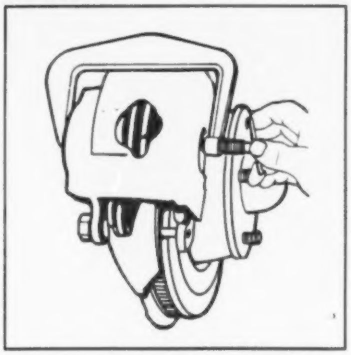
PROCEDURE

Remove a tapered roller cone-and-roller assembly from a wheel with disc brakes

1. Compress the caliper piston to the bottom of its bore in order to provide clearance between the linings and the rotor for caliper removal. Follow the procedure described in the service manual. (See examples A, B, and C below for typical procedures.)

   EXAMPLE A: General Motors — Delco-Moraine Floating Calipers (Figure 3)

FIGURE 3



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A. Place a 7-inch C-clamp over the caliper with the screw end resting on the outboard shoe.

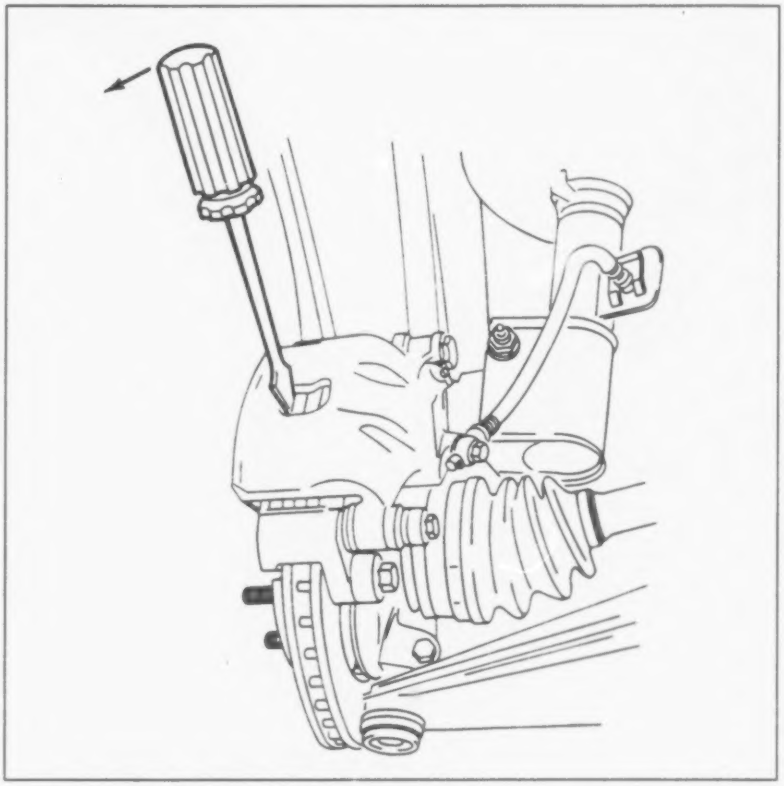
B. Turn the C-clamp screw clockwise against the outer shoe pad until you can no longer turn the screw. This pushes the caliper outward by bottoming the piston in its bore and provides rotor clearance.

NOTE: If the pads are completely covered by the caliper, you will not be able to use a C-clamp and must use a flat bladed pry bar. Place the pry bar between the inside pad and the rotor and pry inward against the pad toward the piston. Pry only enough to loosen the caliper assembly so that it can be removed. Use care not to damage the rotor or piston dust boot.

C. Remove the C-clamp.

EXAMPLE B: Ford — Fixed Guide Pin Caliper (Figure 4)

FIGURE 4



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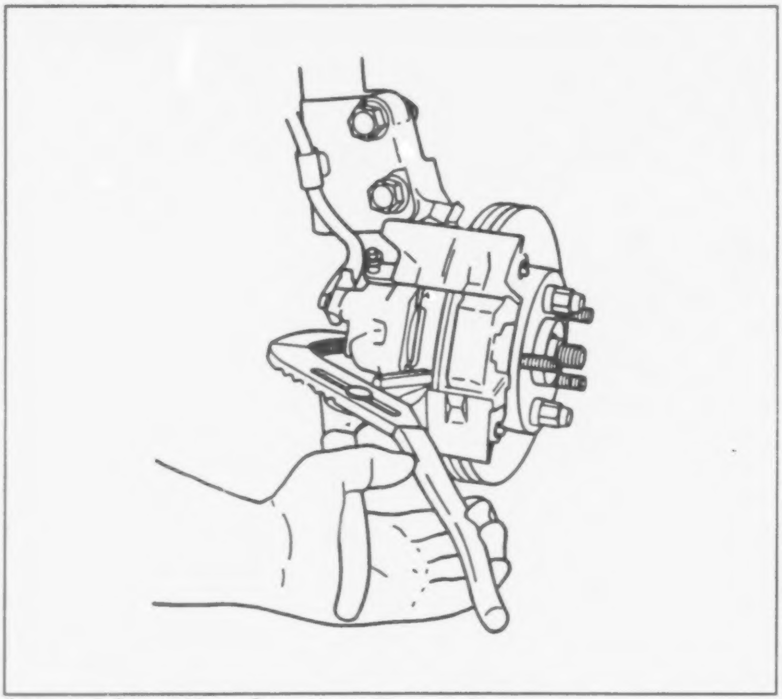
- Use a screwdriver to pry the caliper outboard.

EXAMPLE C: General Motors — 3257 Series Fixed Guide Pin Caliper (Figure 5)

FIGURE 5



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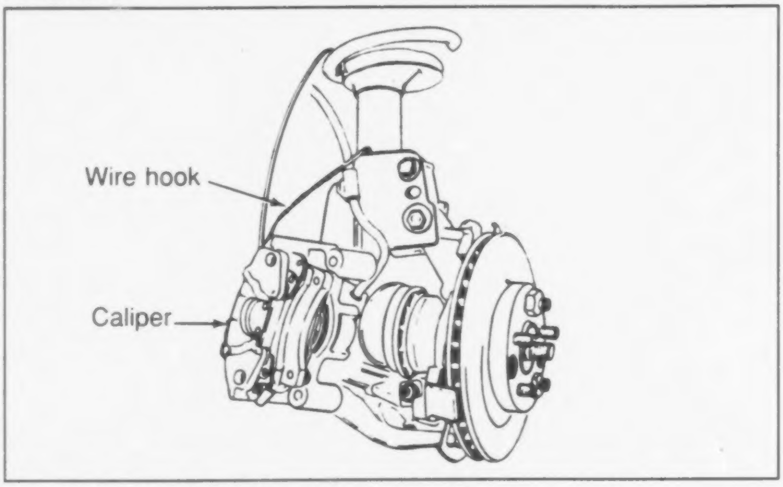
- Place 12-inch adjustable pliers over the inboard brake shoe tab and the inboard caliper housing and squeeze the handles.

2. Remove the caliper mounting hardware.

3. Remove the caliper from its position over the rotor and suspend it from a convenient point with mechanic's wire to prevent damage to the brake line. (Figure 6)

FIGURE 6



Wire hook
Caliper

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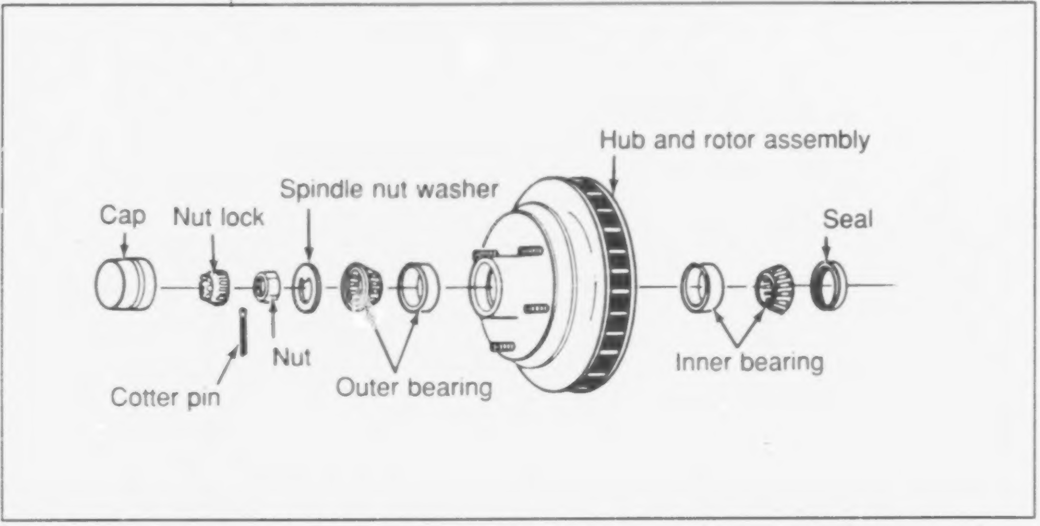
4. Remove the dust cap, spindle nut, cotter pin, and nut lock (if so equipped) as directed in Job Sheet 1. (Figure 7)

FIGURE 7



Hub and rotor assembly
Spindle nut washer
Cap
Nut lock
Seal
Nut
Cotter pin
Outer bearing
Inner bearing

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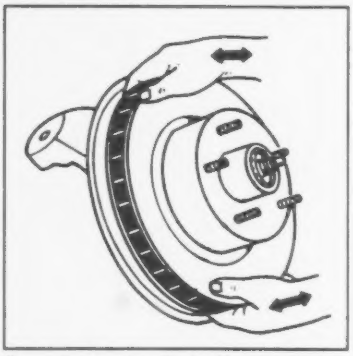
5. Remove the spindle nut with a combination wrench.

6. Use your fingers to pull the washer off and slide the outer bearing cone-and-roller assembly off the spindle.

   NOTE: You may have to rock the rotor back and forth as shown in Figure 8. Rocking the rotor slides the outer cone-and-roller assembly out on the spindle to a position that enables you to grasp it with your fingers.

FIGURE 8



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CAUTION

Because each cone-and-roller assembly sets up a wear pattern in its outer race, the assembly and race are a matched set. Keep each cone and roller assembly with its own outer race (still in the hub): do not mix them and do not reinstall them on the opposite spindle.

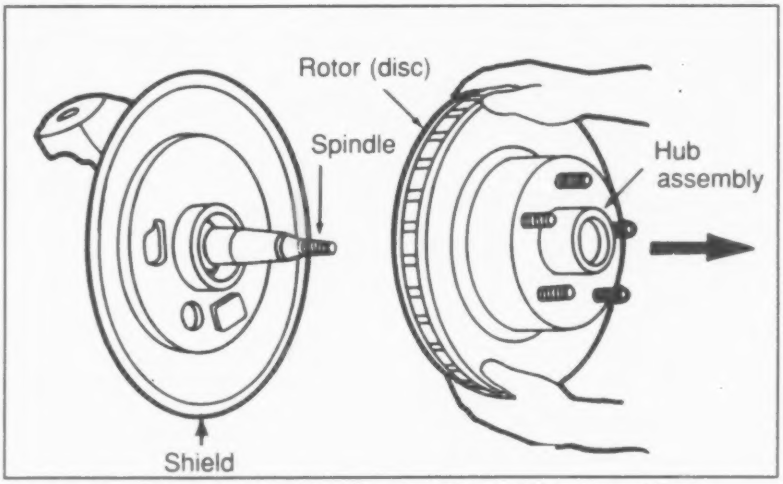
7. Place the outer cone-and-roller assembly on a clean shop towel or piece of paper.

CAUTION

If the vehicle is equipped with an anti-lock braking system, use extreme care to avoid damaging the sensor components.

8. Grasp the rotor with both hands and carefully pull it off the spindle, taking care not to scrape the rotor against the spindle, damaging spindle threads. (Figure 9)

FIGURE 9



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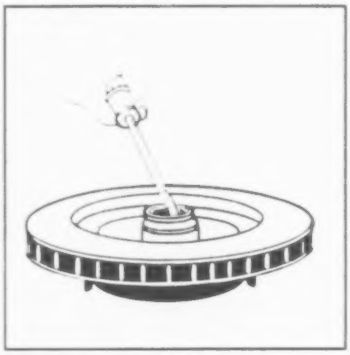
9. Place the rotor on a clean area of the workbench with the inside of the rotor facing up.

10. Using a seal remover, pry bar, or claw hammer, carefully pry out the inner seal. (Figure 10)

11. Lift out the inner cone-and-roller assembly with your fingers.

FIGURE 10

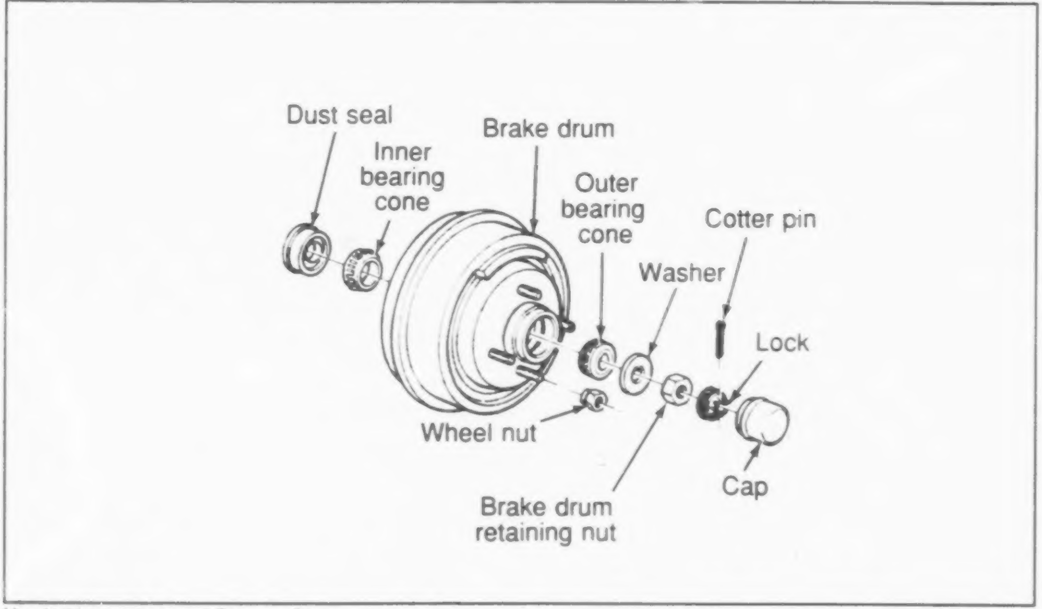


PROCEDURE

Remove a tapered roller cone-and-roller assembly from a wheel with drum brakes

1. Release the parking brake from inside the vehicle.
2. Remove the dust cap, spindle nut, cotter pin, and nut lock (if so equipped) in accordance with Job Sheet 1. (Figure 11)

FIGURE 11


Dust seal
Inner bearing cone
Brake drum
Outer bearing cone
Cotter pin
Washer
Lock
Wheel nut
Cap
Brake drum retaining nut

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3. Remove the spindle nut with a combination wrench.
4. Use your fingers to pull off the washer and slide the outer bearing cone-and-roller assembly off the spindle.

NOTE: You may have to rock the brake drum back and forth to slide the outer cone-and-roller assembly to a position that enables you to grasp it with your fingers.

CAUTION

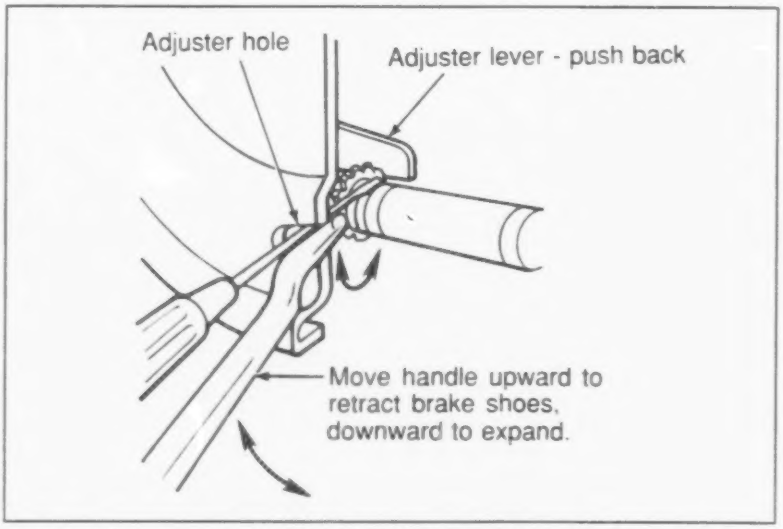
Because each cone-and-roller assembly sets up a wear pattern in its outer race, the assembly and race are a matched set. Keep each cone and roller assembly with its own outer race (still in the hub) do not mix them and do not reinstall them on the opposite spindle.

5. Place the outer cone-and-roller assembly on a clean shop towel or piece of paper.

6. Grasp the brake drum with both hands and carefully pull it off the spindle, taking care not to scrape the drum against the spindle, because this could damage the threads on end of the spindle.

   NOTE: If more clearance between the brake shoes and the drum is needed in order to remove the drum, remove the plug from the access hole in the backing plate and rotate the star wheel with an upward motion, using a brake adjusting spoon. (Figure 12)

FIGURE 12


Adjuster hole
Adjuster lever - push back
Move handle upward to retract brake shoes, downward to expand.

Reproduced by permission. COMPLETE BRAKE SYSTEMS, by Robert Scharff, Delmar Publishers, Inc., Copyright 1984

7. Use an approved asbestos dust removal system to remove all dust particles from the drum and backing plate.

8. Place the drum on a clean area of the workbench with the inside of the drum facing up.

9. Using a seal remover, pry bar, or claw hammer, carefully pry out the inner seal.

PROCEDURE

Clean and inspect a bearing assembly

1. Use a shop towel to wipe excess grease off each bearing assembly.

2. Soak each assembly in an approved cleaning solvent, taking care not to mix right and left sets.

CAUTION

Always use a cleaning solvent recommended by the vehicle manufacturer. **Never** use gasoline or any other volatile liquid as a cleaning solvent. Such liquids are fire hazards and can be harmful to the skin and eyes.

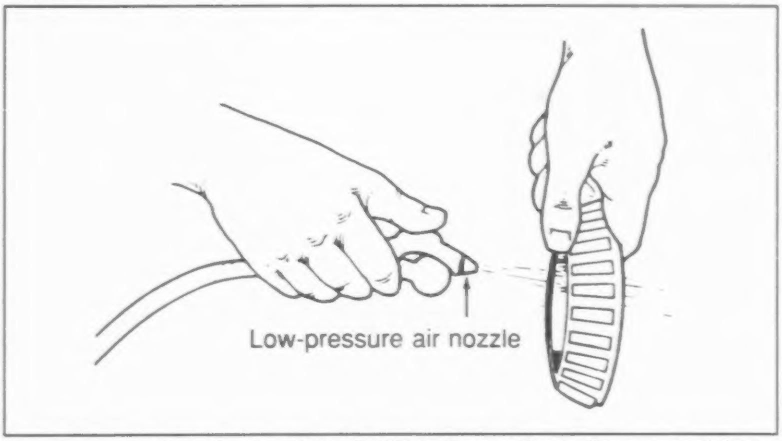
3. After the bearing assemblies have soaked, scrub each assembly with a parts cleaning brush until the assembly is clean.

4. Using a low-pressure nozzle, blow out any remaining dirt particles and solvent from each assembly. (Figure 13)

CAUTION

Do not spin the rollers with compressed air. This could damage the rollers or cause the assembly to fly apart.

FIGURE 13



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5. Using a shop towel and an approved cleaning solvent, carefully clean grease and dirt from the hub, races, and spindle so that they will not contaminate the clean bearing assemblies when they are installed later.

6. Visually inspect each bearing assembly for the following defects: (Refer to Supplement 2 as necessary.)

   - Cage damage or wear
   - Roller wear
   - Frettage
   - Brinnelling
   - Etching
   - Indentations
   - Fatigue spalling
   - Galling

   NOTE: If the bearing rollers or races are defective, you must replace the entire bearing assembly.

7. Coat the bearing rollers and races with light oil to prevent bearing surface damage.

   CAUTION

   Verify that the bearing assembly is completely dry and free of all solvent before any lubricant is applied. Failure to comply could cause the lubricant not to stick to rollers and could cause bearing damage.

8. Replace each cone-and-roller assembly in its original position on the hub and using your fingers, push and turn each assembly to check for roughness.

9. If you detect roughness, rinse and dry the assembly again, relubricate, and recheck it.

10. If you still detect roughness, replace the defective wheel bearing assembly following the procedure outlined below; if you do not detect roughness, continue with the inspection.

11. Place the cone-and-roller assemblies on a clean shop towel or on paper to protect them from dust and dirt.

12. While each bearing cup is still seated in the hub, inspect it for the following defects:

    - Hairline cracks
    - Pits or indentations
    - Heavy wear patterns
    - Dark bluish heat discoloration
    - Light brown to black stain discoloration

13. If the race is in good condition, coat it with a thin layer of wheel bearing grease and leave it in place; if the race is defective, replace the entire bearing following the procedure outlined below.

PROCEDURE

Replace wheel bearing assemblies

1. With the correct side facing up, place the rotor or drum on wooden blocks.

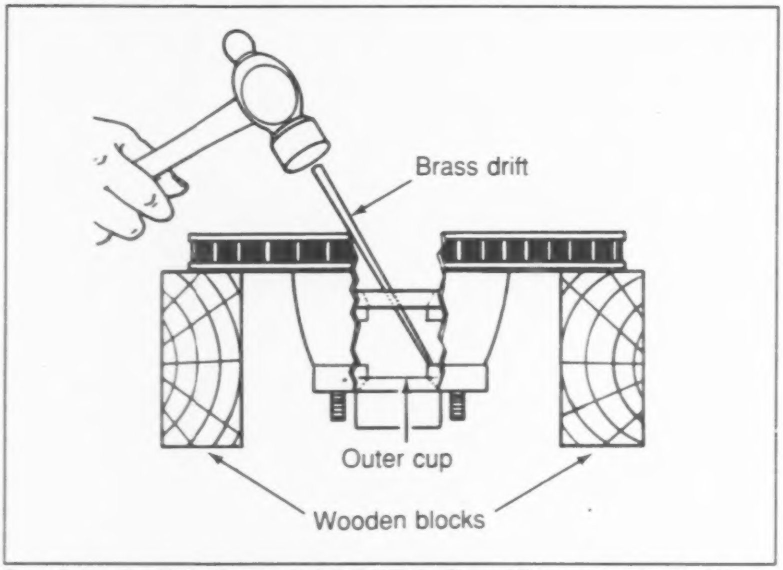
    NOTE: When removing the inner bearing race, position the rotor or drum with the outside facing up. When removing outer bearing race, position the rotor or drum with the inside facing up.

2. Using a brass drift and hammer, gently tap first on one side of the race and then on the other until the race comes out of hub. (Figure 14)

    CAUTION

    Do **not** allow the race to become cocked, or it will jam in the hub. Being careful to tap from one side to another will help prevent cocking. The steel race is made of a much harder metal than the hub, therefore if the race becomes cocked, it can distort the hub, preventing proper fit of a replacement race and necessitating hub replacement.

FIGURE 14



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3. Repeat the procedure to remove other race(s).

4. Use an approved cleaning solvent to clean the areas of the hub where the races will be installed; dry the hub with low-pressure compressed air.

   NOTE: The inside of the hub should be clean, dry, and free of all grease and solvent before the new races are installed.

5. With the correct side facing up, place the rotor or drum on wooden blocks.

   NOTE: When installing the inner bearing race, position the rotor or drum with the inside facing up. When installing the outer bearing race, position rotor or drum with the outside facing up.

6. Install the race using a bearing driver and hammer, being careful to prevent the race from becoming cocked in the hub.

   NOTE: If the race should become cocked in the hub, carefully use a brass drift and hammer to tap the race back into proper alignment, then continue using a bearing driver until the race is firmly seated.

7. Wipe the race with a clean shop towel and coat it with the proper lubricant.

PROCEDURE

Pack a bearing assembly using a bearing packer

NOTE: Even new bearing assemblies must be packed. Be sure to repack the assemblies with only the wheel bearing grease specified by the vehicle manufacturer. Read the container label or check the manufacturer's specified lubricant to be sure that you are using the proper grease. Do not mix types of greases.

1. Install the cone-and-roller assembly in the bearing packer, following packer manufacturer's directions.

2. Use the packer to apply wheel bearing grease until all assembly cavities are filled.

3. Remove the assembly from the packer and apply a coat of grease to the inner and outer edges of the bearing cage.

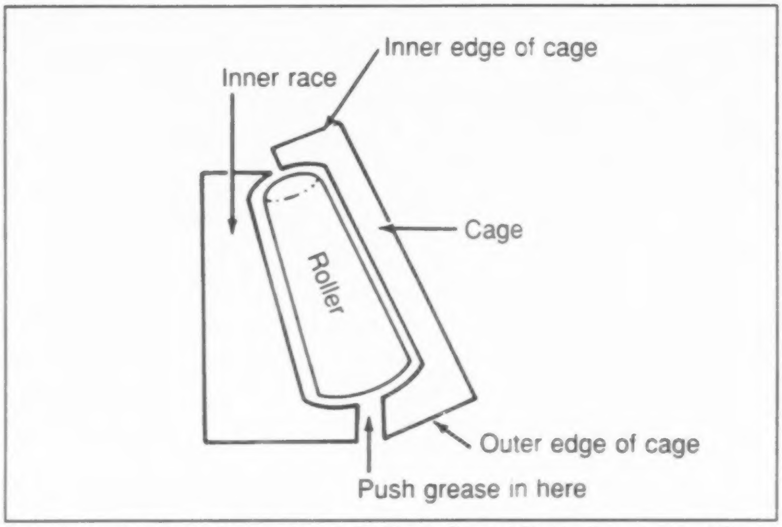
4. Repeat the packing procedure on each cone-and-roller assembly.

PROCEDURE

Pack a bearing assembly by hand

1. Thoroughly work the grease into the cone-and-roller assembly until all spaces between the cage and rollers are filled and grease comes out the top. (Figure 15)

FIGURE 15


Inner edge of cage
Inner race
Cage
Roller
Outer edge of cage
Push grease in here

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2. With your fingers, apply a thin coat of grease to the inner and outer edges of the cage.

PROCEDURE **Install a packed cone-and-roller assembly and a grease seal**

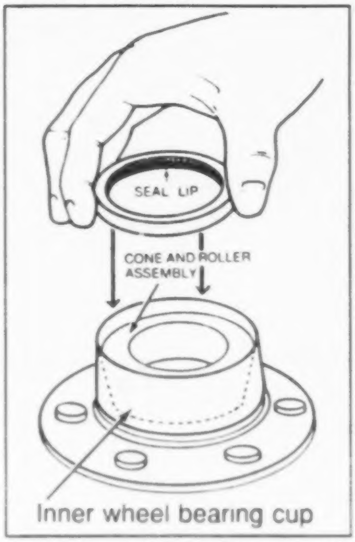
1. Apply a thin coat of wheel bearing grease to the inside of the hub and bearing races.

2. Place the packed inner cone-and-roller assembly into the hub with the tapered end facing inward toward the hub recess. (Figure 16)

CAUTION

Be sure to replace each cone-and-roller assembly in the same hub from which it was originally removed. Interchanging cone-and-roller assemblies between hubs causes each cone-and-roller assembly to operate in a different outer race than was originally used. This could produce excessive bearing wear or bearing failure.

FIGURE 16



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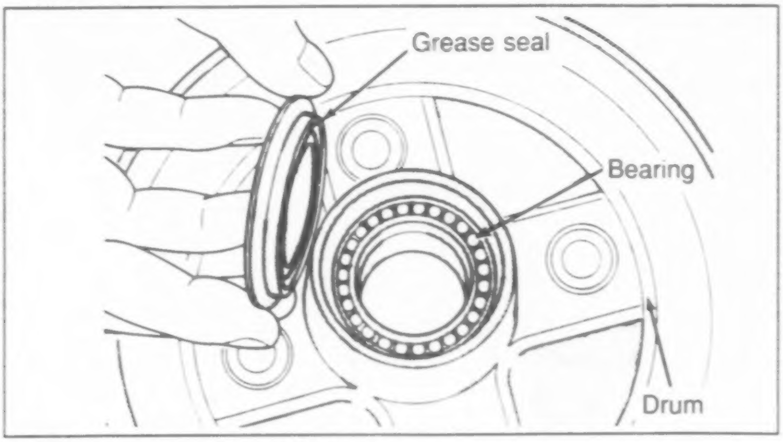
3. Spread a thin coat of bearing grease around the seal lip (inner surface of seal) of the replacement seal.

4. Position the seal with the lip edge facing inward toward the cone-and-roller assembly. (Figure 17)

FIGURE 17



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5. Install the seal with a seal driver, gently tapping the driver with a steel hammer until the seal is firmly in place with the upper lip flush with the hub.

CAUTION

Always tap gently when performing this procedure. Heavy blows will damage the seal.

PROCEDURE **Install the brake rotor or drum and the tire and wheel assembly**

1. Grasp the rotor or drum with both hands and carefully slide it over the spindle, taking care not to allow the interior of the drum or rotor hub to contact and damage the threaded end of the spindle.

   NOTE: As the drum or rotor reaches the part of spindle with the largest diameter, you will feel some resistance. Push the rotor or drum firmly past this point.

2. Insert the packed outer cone-and-roller assembly into the hub with the tapered end facing toward the center of hub.
3. Place the washer and spindle nut on the spindle and finger-tighten the nut.
4. If disc brakes are used, install the caliper assembly and adjust the parking brake cable.
5. Install the tire and wheel assembly and finger-tighten the lug nuts until the assembly is snug against the hub.
6. Adjust the wheel bearings in accordance with Job Sheet 1.
7. Clean the dust cap with an approved cleaning solvent.
8. Center the dust cap on the hub and use a rubber mallet to tap the dust cap onto the hub.
9. If drum brakes are used, adjust star wheels and the parking brake cable.

10. Remove the cover from the master cylinder reservoir and verify that the fluid level is at least ¾ full. Add clean approved brake fluid if necessary.

CAUTION

Do not spill brake fluid on chrome or painted surfaces as it may damage these finishes. Brake fluid is poisonous; avoid contact with skin, and do **not** allow fluid to get into eyes. Brake fluid is flammable. Keep brake fluid away from fire.

11. Replace the master cylinder reservoir diaphragm and cover.

12. Pump the brake pedal several times to be sure the brakes are functioning.

13. Lower the vehicle to floor.

14. Torque the lug nuts in a criss-cross pattern to the manufacturer's specifications.

15. Install the wheel covers.

16. Road test the vehicle.

CAUTION

Make a series of low-speed stops to be sure that brakes are safe for road testing.

17. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

SERVICE TAPERED ROLLER WHEEL BEARINGS

JOB SHEET 1

Adjust wheel bearings.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	______	______
2. Properly prepared the vehicle.	______	______
3. Torqued spindle nut to manufacturer's specifications and seated bearings.	______	______
4. Reinstalled nut lock and installed new cotter pin.	______	______
5. Reinstalled dust cap on the hub and replaced the wheel cover.	______	______
6. Completed service correctly.	______	______
7. Observed safety rules and precautions.	______	______
8. Cleaned work area and returned equipment and materials to proper storage.	______	______

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TESTS

SERVICE TAPERED ROLLER WHEEL BEARINGS I

JOB SHEET 2

Remove, clean, inspect, pack, and install non-drive wheel bearings and replace seals.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	______	______
2. Properly prepared the vehicle.	______	______
3. Removed non-drive wheel bearing assembly correctly.	______	______
4. Cleaned and inspected bearing assembly following outlined procedures.	______	______
5. Packed cone-and-roller assembly following outlined procedures.	______	______
6. Installed cone-and-roller assembly and grease seal correctly.	______	______
7. Installed brake rotor or drum and tire and wheel assembly following outlined procedures.	______	______
8. Observed safety rules and precautions.	______	______
9. Cleaned work area and returned equipment and materials to proper storage.	______	______

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

WRITTEN TEST

SERVICE TAPERED ROLLER WHEEL BEARINGS I

NAME ______________________ SCORE ________

OBJECTIVE 1

Select definitions of terms associated with wheel bearings.
Select the best answer for each term.

______1. **cup**

A. Assembly that reduces friction between revolving and nonrevolving parts, allowing smooth movement of the parts
B. The part of a bearing assembly located on the outer side of the bearing rollers or balls and just inside the hub; installed in the hub with a press fit
C. Assembly allowing bearings to revolve faster at higher rates of speed
D. Part which covers the bearing assembly and protects the assembly from contamination

______2. **packing**

A. The process of installing a cone-and-roller assembly on the hub
B. The installation of a cup with a tight or interference fit requiring more than hand pressure to install
C. The process of cleaning old grease from the bearings and then forcing new wheel bearing grease into the openings between the races and the cage
D. The process of forcing as many bearings into the roller as possible

______3. **bearing**

A. The amount and direction of load applied to the vehicle wheels
B. An assembly that reduces friction between revolving and nonrevolving parts, allowing smooth movement of the parts
C. The surface or path around which vehicle wheels revolve
D. A part designed to reinforce the hub and outer race

______4. **cone-and-roller assembly**

A. The part of a roller bearing that contains the cone (inside race), rollers, and roller cap; installed on the spindle with either a press or push fit
B. The part of a roller bearing that contains the bearing race (cup), cage, and rollers; installed on the spindle with a press fit
C. The part of a roller bearing that contains the cone (inside race), bearing race (cup), and rollers; installed on the spindle with a push fit
D. The part of a roller bearing that contains the cone (inside race), cage, and rollers; installed on the spindle with a push fit

______5. **antifriction bearing**

A. A bearing assembly using roller bearings rather than ball bearings; used to reduce friction between two revolving parts
B. A friction bearing which has been coated with a special antifriction material to reduce friction between revolving parts
C. A bearing consisting of rollers or balls situated between two races, allowing the load to roll on balls or rollers, thus minimizing friction
D. A bearing consisting of both roller and ball bearings and attached to a bearing cone

______6. **end play**

A. The amount of radial runout in a wheel due to clearance in the bearings
B. The difference between the axial movement of the front wheels and the rear wheels
C. Vehicle pull caused by loose wheel bearings
D. The amount of axial movement in a hub due to the clearance in the bearings

______7. **press fit**

A. The installation of rollers in a bearing cone with a tight fit requiring more than hand pressure to install
B. The installation of a cone-and-roller assembly with a tight or interference fit requiring more than hand pressure to install
C. The installation of a cone-and-roller assembly with a light fit that can be installed with hand pressure
D. The installation of a cup (other race) with a tight or interference fit requiring more than hand pressure to install

______8. **race**

A. That part of a bearing assembly that connects the bearing rollers
B. The amount and direction of load applied to vehicle wheels
C. The surface or path on which bearing balls or rollers move
D. The speed at which the bearing rotates inside the hub

______9. **preload**

A. The amount of lubricant contained in an antifriction bearing
B. To adjust the bearings so that they will work under mild pressure
C. To adjust the bearing correctly before seating the bearing
D. To adjust the axial movement of bearings on the hub

______10. **push fit**

A. The installation of a cup with a tight or interference fit requiring more than hand pressure to install
B. The installation of a cone-and-roller assembly with a light fit requiring only hand pressure to install
C. The installation of a cup with a medium to light fit that can be installed with a special push fit tool
D. The installation of rollers in a bearing cone with a light fit which requires only hand pressure to install

_____11. **viscosity**

A. A measure of how easily a liquid flows
B. The amount of axial movement in a hub due to clearance in the bearings
C. Stickiness
D. A measure of a fluid's weight

OBJECTIVE 2

State the purposes of wheel bearings. Write your answers in the following blanks.

1. ____

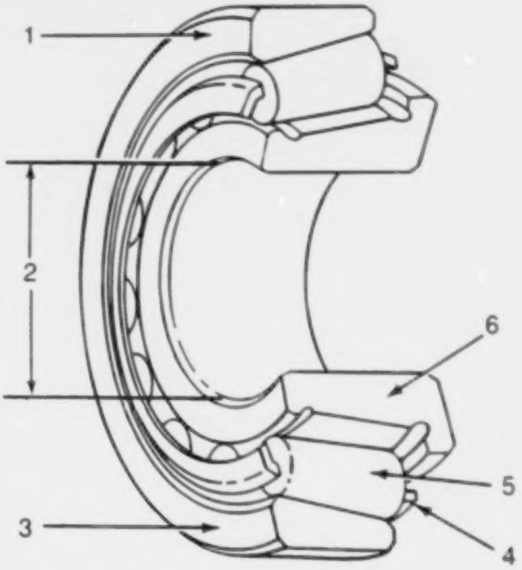
____

2. ____

____

OBJECTIVE 3

Label the parts of a tapered roller wheel bearing assembly. Choose the correct name from the list below for each of the numbered parts in the following illustration.



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______1. A. Bore

______2. B. Cage or separator

______3. C. Cone

______4. D. Cup

______5. E. Face

______6. F. Tapered roller

OBJECTIVE 4

List the properties of wheel bearing grease. Write your answers in the following blanks:

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

6. ______________________________

WRITTEN TEST ANSWERS

SERVICE TAPERED ROLLER WHEEL BEARINGS

I

OBJECTIVE 1

1. B
2. C
3. B
4. D
5. C
6. D
7. D
8. C
9. B
10. B
11. A

OBJECTIVE 2

The answers should include both of the following:

- To reduce friction between the revolving wheel hub and the spindle
- To spread vehicle loads over a larger surface area

OBJECTIVE 3

1. D
2. A
3. E
4. B
5. F
6. C

OBJECTIVE 4

The answers should include all of the following:

- Water-resistant
- Heat-resistant, will not change viscosity as the temperature rises
- Stable at high temperatures, will not separate as the temperature changes
- Noncorrosive
- Adheres to smooth surfaces
- Will not form acids under adverse conditions

OBJECTIVE SHEET

SERVICE STEERING SYSTEMS

II

INTRODUCTION

The steering system of a vehicle performs many purposes. It enables the driver to easily and accurately direct the vehicle while driving. Along with the front suspension system, it also helps keep the tire and wheel assemblies positioned correctly. Because steering system problems can affect both the driver's ability to steer the vehicle and wheel alignment, the steering system must be in good condition and perform correctly before wheel alignment can be checked. Therefore, the steering and suspension specialist must be able to inspect the steering system, accurately diagnose problems, and service the steering system to correct these problems.

PREREQUISITES

Before studying this unit, the student should have successfully completed Unit 1, *Service Tapered Roller Wheel Bearings*.

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose manual and power steering system problems and service both types of systems. The student will demonstrate these competencies by completing the assignment sheets, job sheets, and written test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to show the ability to:

1. Select definitions of terms associated with the steering system.
2. State the purposes of the steering system.
3. Label the parts of a collapsible steering column.
4. Label the parts of a steering wheel assembly with tilting capabilities.
5. Match the elements of front-end geometry to their descriptions.
6. Label the parts of steering linkage designs.
7. Label the parts of steering gears.
8. Match power steering system components to their functions.
9. Label the parts of a power steering pump.

10. Identify types of power steering pumps.

11. Describe types of power steering systems.

12. Identify types of constant-velocity joints.

13. Diagnose steering column problems. (Assignment Sheet 1)

14. Diagnose manual steering system problems. (Assignment Sheet 2)

15. Diagnose power steering system problems. (Assignment Sheet 3)

16. Demonstrate the ability to:

    A. Inspect and replace steering column components. (Job Sheet 1)

    B. Inspect and replace a pitman arm. (Job Sheet 2)

    C. Inspect, replace or repair, and install an idler arm and mounting. (Job Sheet 3)

    D. Inspect and replace a center link. (Job Sheet 4)

    E. Inspect and replace a tie-rod assembly. (Job Sheet 5)

    F. Inspect and replace a steering damper. (Job Sheet 6)

    G. Adjust, or replace and adjust, a power recirculating-ball type steering gear. (Job Sheet 7)

    H. Inspect and replace a bellows boots. (Job Sheet 8)

    I. Replace a manual rack-and-pinion steering gear. (Job Sheet 9)

    J. Perform a power steering pressure test. (Job Sheet 10)

    K. Replace a power rack-and-pinion steering assembly. (Job Sheet 11)

    L. Recondition a power steering pump. (Job Sheet 12)

    M. Recondition constant-velocity joints. (Job Sheet 13)

PREPARATION

- Review unit and plan presentation. Study the specific objectives to determine the order in which you will present the objectives.

  Review the teaching suggestions given in the Delivery and Application sections and plan classroom activities. Also note suggestions for media and supplemental materials.

  Plan your presentation to take advantage of student learning styles and accommodate students with special needs.

- Many multiple-choice test questions (in the Pretests, Assignment Sheets, and Written Test) for this curriculum have been written in a style that is similar to the questions on the ASE certification test. Like ASE questions, the student should select the item that **BEST** answers the question. *The student should make no additional assumptions about a question other than those specifically given in the question.* A special effort has been made to provide good distracters for each question which will make the student think through the answer. It is suggested that the instructor review the answers to every test before reviewing the test with the students so that he or she is not caught off guard by such distracters.

- Obtain films, videotapes, and other media to supplement instruction of this unit. See ordering information in the Suggested Resources section. Include in your selection media that demonstrate job sheet skills. Videotape your own demonstrations of job sheet procedures if you are unable to obtain suitable media.

- Obtain competency profiles.

  NOTE: Competency profiles for this book are available from the Curriculum and Instructional Materials Center, Oklahoma State Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364.

- Prepare the classroom and shop. Display posters, charts, safety signs, etc., that emphasize steering system service. Have articles, specification guides, mock-ups, and other references about steering system service available for student use. Display various types of steering gears.

- Discuss the purpose of pretesting with the students. Explain that they will be asked to complete a written pretest and they will be required to demonstrate assignment sheet competencies and job sheet skills as part of the pretesting process.

- Provide students with the equipment and materials necessary to complete the pretest. Administer the pretest.

- Assess student competencies. Consider the results of student assessments as you prepare your presentation for each objective.

DELIVERY

Unit introduction

- Discuss the introduction to the unit. (See Objective Sheet.)

- Discuss the unit objective and then the specific objectives. Emphasize how accomplishing the specific objectives will lead to meeting the unit objective and how reaching the unit objective is vital to becoming an automotive steering and suspension specialist. Also relate the objective to your introduction and to material previously covered.

Objective 1 Select definitions of terms associated with the steering system.

- Show the students examples of as many of the terms listed in this objective as possible.

- Refer students to the illustrations of parallelogram and rack-and-pinion linkages in Objective 6. Discuss the steering linkage components that are defined in this objective.

Objective 2 State the purposes of the steering system.

- Discuss each of the purposes listed. Ask the students if they can think of examples for each of these purposes.

- Discuss the "One step more . . ." box material.

Objective 3 Label parts of a collapsible steering column.

- Discuss the functions and purposes of each of the collapsible steering column parts.

- Discuss the boxed material, "Steering Columns," and give examples of the types of vehicles that use each of the collapsible steering columns shown.

Objective 4 Label the parts of a steering wheel assembly with tilting capabilities.

- Display a mock-up or cutaway steering wheel assembly for the students to study or take the students to the shop and remove the steering wheel from a vehicle so that they can see the actual parts.

- Show the students service manual illustrations which show the many parts that make up a steering wheel assembly.

Objective 5 Match the elements of front-end geometry to their correct descriptions.

- Review geometric terms such as *angle*, *radius*, etc. with the students. Refer students to Unit A-4, Apply Related Math and Measuring, in *Introduction to Automotive Service* if necessary.

- Explain the importance of understanding these terms and emphasize the fact that as steering and suspension specialists, they will be using the terms frequently.

- Discuss *camber* and *caster*, and explain the difference between negative camber or caster and positive camber and caster.

- Explain that *steering-axis inclination (SAI)* and *Kingpin inclination (KPI)* are the same. Refer to Figure 5 and explain to the students that the SAI angle is formed by a vertical line through the wheel and a line through the ball joints; KPI angle is formed by a vertical line through the wheel and a line through the kingpin.

- Discuss the boxed material, "Alignment."

Objective 6 Label the parts of steering linkage designs.

- Discuss the features and parts of each design.

- Refer the students to Objective 1 for the definitions of the primary parts. Explain how each steering linkage design operates.

- List types of vehicles that have parallelogram linkage. Explain that in the past there were several variations of the parallelogram linkage design, but the one shown in this objective is the only parallelogram design found on modern vehicles.

- List the types of vehicles that have rack-and-pinion linkage. Explain that this design was first seen on imported vehicles but is now commonly used on several smaller vehicles.

- Explain the advantage of having rack-and-pinion steering, rather than parallelogram steering, on smaller vehicles.

Objective 7 Label the parts of steering gears.

- Discuss the parts of each type of steering gear illustrated.

- Show the students disassembled gears and explain how each gear transfers steering wheel motion to the wheels.

Objective 8 Match power steering system components to their functions.

- Combine this objective with Objective 11 and discuss the function and location of each component.

- Discuss the term *power steering* and explain that it is actually power-assisted steering. Explain that after a certain amount of steering effort is applied, the power steering system is activated and provides most of the force required to steer the vehicle.

- Show the video, *Operation and Diagnosis of Steering Systems.*

Objective 9 Label the parts of a power steering pump.

- Display a disassembled pump. Show the different parts and explain the function of each.

- Using an actual pump, point out areas where leakage is likely to occur.

- Discuss the flow of the power steering fluid within the pump.

- Combine this objective with Objective 10 and explain the operation of a power steering pump. Explain that all types basically operate in the same manner: the rotor turns in an oval body.

Objective 10 Identify types of power steering pumps.

- Discuss each type of pump presented in this objective. Tell students instances where each is used.

- Show the students the rotors of disassembled pumps. Explain that the basic operation is the same although the rotor may have vanes, slippers, or rollers.

Objective 11 Describe types of power steering systems.

- Discuss the two types of power steering systems. Explain to the students that these types differ because of the location of the control valve and the power piston (or power cylinder) in each system.

- Discuss the illustrations of the systems and point out the location of the control valve and the power piston or cylinder in each illustration.

- Discuss the importance of being able to identify the type of steering system in a vehicle.

Objective 12 Label types of constant-velocity joints.

- Discuss the four types of constant-velocity (CV) joints shown in this objective. Explain the difference between the plunging type and the fixed type.

APPLICATION

Objective 13 Diagnose steering column problems. (Assignment Sheet 1)

- Have the students study Supplement 1, Steering Column Diagnostic Chart. Review this information with them, explaining each condition listed.

- Display a variety of service manuals and have the students find the steering column diagnostic or troubleshooting information.

- Discuss the introduction to Assignment Sheet 1. Have the students complete Assignment Sheet 1. When all students have completed the assignment, discuss it in class.

Objective 14 Diagnose manual steering system problems. (Assignment Sheet 2)

- Explain that it is an important part of the service technician's job to accurately diagnose manual steering system problems. Explain that many manual steering problems also occur in power steering systems.

- Show the film, *Rack and Pinion*, and *TRW Technology—The Source for Rack and Pinion.*

- Have the students study Supplement 2, Diagnostic Chart for Steering Systems. Review this information with the students, explaining each condition listed. Point out those conditions and causes associated *only* with power steering systems.

- Explain to the students that problem conditions could be the result of steering gear problems or steering linkage problems.

- Display a variety of service manuals and have the students locate troubleshooting charts for manual steering systems.

- Discuss the introduction to Assignment Sheet 2. Have the students complete Assignment Sheet 2. When all students have completed the assignment, discuss in it class.

Objective 15 Diagnose power steering system problems. (Assignment Sheet 3)

- Show the filmstrip, *Car and Light Truck Power Steering Diagnosis.*

- Use the transparencies in *Car Power Steering Diagnosis and Adjustment* in your discussion.

- Review the information in Supplement 2, Diagnostic Chart for Steering Systems with the students. Discuss the checks that should be made when diagnosing a problem with the power steering pump. Also explain each of the conditions listed.

- Explain to the students that problem conditions could be the result of steering gear, steering linkage, or pump problems.

- Display a variety of service manuals and have students locate troubleshooting charts for power steering systems.

- Discuss the introduction to Assignment Sheet 3. Have the students complete Assignment Sheet 3. When all students have completed the assignment, discuss it in class.

Objective 16A Inspect and replace steering column components. (Job Sheet 1)

- Look through various vehicle manufacturers' service manuals and show the students illustrations of the different designs of steering columns. Point out and discuss the many controls associated with steering columns.

- Discuss the proper handling of the steering column. Emphasize the fact that excessive pressure could cause the column to collapse.

- Discuss the equipment and materials used in Job Sheet 1. Review applicable safety rules and precautions and the guidelines given in the job sheet introduction.

- Demonstrate Job Sheet 1. Have the students practice Job Sheet 1 until they are ready to take the practical test.

Objective 16B Inspect and replace a pitman arm. (Job Sheet 2)

- Show the students various pitman arm pullers and demonstrate the use of each. Discuss the particular types of pullers that can be used on a variety of makes and models of vehicles.

- Demonstrate how to check and adjust wheels so they are in the straight ahead position.

- Show the students the types of nuts used in the installation. Discuss the difference between self-locking nuts and castellated nuts with cotter pins.

- Explain that linkage looseness could be attributed to loose or worn connections or to a damaged pitman arm, idler arm, or center link.

- Show the students a pitman arm and discuss its size and shape. Explain that it is difficult to determine if it is bent unless you remove it and compare it to a pitman arm that is known to be good.

- Discuss the equipment and materials used in Job Sheet 2. Review applicable safety rules and precautions and the guidelines given in the job sheet introduction.

- Demonstrate Job Sheet 2. Have the students practice Job Sheet 2 until they are ready to take the practical test.

Objective 16C Inspect, replace or repair, and install an idler arm and mounting. (Job Sheet 3)

- Explain that linkage looseness could be attributed to loose or worn connections or to a damaged pitman arm, idler arm, or center link.

- Demonstrate the proper use of the hydraulic press in your shop. Point out all controls and safety features. Be sure to discuss safety rules and precautions that should be observed when operating the hydraulic press.

- Show how to mount the idler arm on blocks before using the hydraulic press to remove the bushing.

- Discuss the equipment and materials used in Job Sheet 3. Review the applicable safety rules and precautions and the guidelines given in the job sheet introduction.

- Demonstrate Job Sheet 3. Have the students practice Job Sheet 3 until they are ready to take the practical test.

Objective 16D Inspect and replace a center link. (Job Sheet 4)

- Explain that linkage looseness could be attributed to loose or worn connections or to a damaged pitman arm, idler arm, or center link.

- Discuss the equipment and materials used in Job Sheet 4. Review applicable safety rules and precautions and the guidelines given in the job sheet introduction.

- Demonstrate Job Sheet 4. Have the students practice Job Sheet 4 until they are ready to take the practical test.

Objective 16E Inspect and replace a tie-rod assembly. (Job Sheet 5)

- Explain why it is important to measure the tie-rod assembly before removing tie-rod end(s).

- Explain that a tie-rod end fork will ruin the joint seal and a tie-rod end puller will not. Discuss situations in which each of these tools is used. Have the students look in service manuals to see when each type is used.

- Explain how tie-rod assembly replacement in parallelogram systems and rack-and-pinion systems differ.

- Instruct the students to inspect the bellows boots when they inspect the tie-rod. If replacement is necessary, direct them to Job Sheet 8, Inspect and Replace a Bellows Boots.

- Discuss the equipment and materials used in Job Sheet 5. Review applicable safety rules and precautions and the guidelines given in the job sheet introduction.

- Demonstrate Job Sheet 5. Have the students practice Job Sheet 5 until they are ready to take the practical test.

Objective 16F Inspect and replace a steering damper. (Job Sheet 6)

- Discuss the types of vehicles which may have factory-installed steering dampers and those types to which dampers are often added.

- Explain why it is important that the service specialist select a damper that is specifically designed for the vehicle on which it is to be installed.

- Discuss the equipment and materials used in Job Sheet 6. Review applicable safety rules and precautions and the guidelines given in the job sheet introduction.

- Demonstrate Job Sheet 6. Have the students practice Job Sheet 6 until they are ready to take the practical test.

Objective 16G Adjust, or replace and adjust, a power recirculating-ball type steering gear. (Job Sheet 7)

- Discuss the procedure for replacing and adjusting a manual recirculating-ball steering gear. Explain the similarities and differences between the replacement procedures for manual and power gears.

- Discuss the equipment and materials used in Job Sheet 11. Review applicable safety rules and precautions and the guidelines given in the job sheet introduction.

- Demonstrate Job Sheet 11. Have the students practice Job Sheet 11 until they are ready to take the practical test.

Objective 16H Inspect and replace a bellows boots. (Job Sheet 8)

- Show the students a bellows boot and point out areas where damage or wear is usually evident.

- Discuss the different types of clamps used, especially those requiring special tools for installation.

- Discuss the equipment and materials used in Job Sheet 8. Review applicable safety rules and precautions and the guidelines given in the job sheet introduction.

- Demonstrate Job Sheet 8. Have the students practice Job Sheet 8 until they are ready to take the practical test.

Objective 16I Replace a manual rack-and-pinion steering gear. (Job Sheet 9)

- Display an assortment of racks, including those having tie-rods connecting at the center and at the end.

- Explain that the bushings, mountings, and clamps should be inspected for damage, looseness, or deterioration.

- Emphasize the importance of keeping the steering wheel in the straight-ahead position so that it will not be crooked after replacement is complete.

- Discuss the location of mountings. Rack-and-pinion gears may be attached to either the frame or the body. Some are more difficult to replace because of where they are mounted. For some types, the engine or part of the suspension may have to be removed to replace the gear assembly.

- Discuss the equipment and materials used in Job Sheet 9. Review applicable safety rules and precautions and the guidelines given in the job sheet introduction.

- Demonstrate Job Sheet 9. Have the students practice Job Sheet 9 until they are ready to take the practical test.

Objective 16J Perform a power steering pressure test. (Job Sheet 10)

- Discuss power steering fluid and explain why automatic transmission fluid should not be used in the power steering system. Display both types of fluid and allow the students to feel the consistency of each.

- Demonstrate the use of the pressure testing equipment in your shop. Remind students of the possible consequences of the pressures dealt with during testing and review the safety rules to be followed when using this equipment.

- Discuss the equipment and materials used in Job Sheet 10. Review applicable safety rules and precautions and the guidelines given in the job sheet introduction.

- Demonstrate Job Sheet 10. Have the students practice Job Sheet 10 until they are ready to take the practical test.

Objective 16K Replace a power rack-and-pinion steering assembly. (Job Sheet 11)

- Caution the students not to kink lines during removal and installation. Explain that the lines must be capped to protect the lines and threads and to keep fluid from coming out. Also point out that they should not be uncapped until the lines are reconnected.

- Discuss the equipment and materials used in Job Sheet 11. Review applicable safety rules and precautions and the guidelines given in the job sheet introduction.

- Demonstrate Job Sheet 11. Have the students practice Job Sheet 11 until they are ready to take the practical test.

Objective 16L Recondition a power steering pump. (Job Sheet 12)

- Discuss the equipment and materials used in Job Sheet 12. Review applicable safety rules and precautions and the guidelines given in the job sheet introduction.

- Demonstrate Job Sheet 12. Have the students practice Job Sheet 12 until they are ready to take the practical test.

Objective 16M Recondition constant-velocity joints. (Job Sheet 13)

- Discuss the equipment and materials used in Job Sheet 13. Review applicable safety rules and precautions and the guidelines given in the job sheet introduction.

- Demonstrate Job Sheet 13. Have the students practice Job Sheet 13 until they are ready to take the practical test.

Unit summary activity

- Discuss Activity Sheet 1, Answer General Questions About Steering Systems. The purpose of this activity is to provide students with the opportunity to practice answering questions similar in content and style to those found on the actual ASE certification test. Keep this in mind when discussing the assignment.

- Have the students complete Activity Sheet 1.

EVALUATION

- Give the written test.

- Give the practical tests and evaluate the tests on the forms provided.

- Reteach and retest as required.

- Complete the appropriate section of the competency profiles.

SUGGESTED RESOURCES

Resources used in developing unit

- Bacon, Miles E. *Automotive Steering, Suspension, and Wheel Alignment.* New York: Gregg Division, McGraw-Hill Book Co., 1988.
- Bacon, Miles E. *Steering, Suspension, and Wheel Service. Unit 1: Inspection of Steering, Suspension, and Wheel Parts,* rev. ed. Tallahassee, Florida: State of Florida Department of Education, 1982.
- Billiet, Walter E., and Walter Alley. *Automotive Suspensions, Steering, Alignment, and Brakes,* 5th ed. Alsip, Illinois: American Technical Publishers, Inc., 1982.
- *Chevrolet 10-30 Series, 1986 Light Duty Truck Shop Manual.* Detroit, Michigan: General Motors Corp., Chevrolet Motor Division, 1984.
- *Chilton's Guide to Brakes, Steering, and Suspension, 1980-87.* Radnor, Pennsylvania: Chilton Book Co., 1987.
- Coghlan, David A. *Automotive Chassis Systems: Steering, Suspension, Alignment, and Brakes,* 2nd ed. Boston: Breton Publishers, A Division of Wadsworth, Inc., 1985.
- Crouse, William H., and Donald L. Anglin. *Automotive Brakes, Suspension, and Steering.* New York: Gregg Division, McGraw-Hill Book Co., 1983.
- Crouse, William H., and Donald L. Anglin. *Automotive Mechanics,* 9th ed. New York: Gregg Division, McGraw-Hill Book Co., 1985.
- deKryger, William J., Robert T. Kovacik, and Saverio G. Bono. *Auto Mechanics: Theory and Service.* Cincinnati, Ohio: South-Western Publishing Co., 1986.
- Duffy, James E. *Modern Automotive Mechanics.* South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1985.
- *1986 Caprice, Monte Carlo, El Camino Shop Manual.* Detroit, Michigan: General Motors Corp., 1985.

- *1986 Chrysler Engine-Chassis-Body Service Manual: 1986 Front Wheel Drive Passenger Vehicles; Lancer, Daytona, New Yorker, Dodge 600, Aries, Omni, LeBaron GTS, Laser, LeBaron, Caravelle, Reliant, Horizon.* Centerline, Michigan: Chrysler Corp., 1985.

- *1986 Shop Manual: Caprice, Monte Carlo, El Camino.* Detroit, Michigan: General Motors Corp., Chevrolet Motor Division, 1985.

- *Steering, Suspension, Wheel Alignment and Balance: Student Reference Book.* Centerline, Michigan: Chrysler Corp. Service and Parts Operations, Training Program Development Dept., n.d.

- *Steering, Suspension, and Wheel Service, Unit 2: Adjustment and Replacement of Steering Linkage, Wheel, and Suspension Parts.* Tallahassee, Florida: The Center for Studies in Vocational Education, Florida State University, 1980.

- Stockel, Martin W., and Martin T. Stockel. *Auto Service and Repair.* South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1984.

- *Understanding Constant-Velocity Drive Systems.* Toledo, Ohio: Dana Corp., 1980.

Media

Spelling and definitions of terminology used in automotive service are not standardized. Media selected to supplement and reinforce material taught in this book may or may not use the same spelling and definitions. Although such deviations should not restrict classroom use of supplemental materials, its existence may confuse some students.

- *Car and Light Truck Power Steering Diagnosis and Inspection.* 112-frame filmstrip and 39-minute record. Ford Service Publications, P.O. Box 07150, Detroit, Michigan 48207, phone 1-800-782-4356.

- *Car Power Steering Diagnosis and Adjustment.* 19 full-color transparencies and notes. Ford Service Publications, P.O. Box 07150, Detroit, Michigan 48207, phone 1-800-782-4356.

- *Operation and Diagnosis of Steering Systems*. 31 minutes, video. General Motors Training Materials Department Information, Kent Moore Tool & Equipment Division, SPX Corp., 28635 Mound Road, Warren, Michigan 48092-9923, phone 1-800-468-6657. Information on operating, diagnosing, disassembling, checking, and adjusting steering columns, steering linkage, manual steering gears, and power steering gears and pumps.

- *Rack and Pinion*. 15-minute 16 mm film. Moog Automotive, Inc., c/o Moog Training Center, 6565 Wells Avenue, St. Louis, Missouri 63133. Covers inspection and replacement techniques.

- *TRW Technology—The Source for Rack and Pinion*. 16 mm film. TRW, Inc., Replacement Division, 8001 E. Pleasant Valley Road, Cleveland, Ohio 44131.

WHEEL ALIGNMENT CHECK SHEET

Form 1617 6-80
Supersedes 1617 11-77

NAME ____________________ MAKE ____________ YEAR ________
ADDRESS ____________________ MODEL ____________ COLOR ________
CITY ____________ STATE ________ ZIP ________ LICENSE ____________________
PHONE ____________ OFFICE PHONE ____________ MILEAGE ____________ DATE ________

PRE-ALIGNMENT INSPECTION

- ☐ NORMAL VEHICLE LOAD
- ☐ TIRE PRESSURES
- ☐ UNEVEN & WORN TIRES
- ☐ WHEEL BEARINGS
- ☐ DRAGGING BRAKES
- ☐ SHOCK ABSORBERS (STRUTS)
- ☐ BALL JOINTS (KING PINS)
- ☐ IDLER ARM
- ☐ STABLIZER
- ☐ TIE RODS & ENDS
- ☐ STEERING ARMS
- ☐ PITMAN ARM
- ☐ SPINDLE
- ☐ BUSHINGS
- ☐ REAR AXLE
- ☐ STEERING WHEEL

LEFT FRONT	CAMBER ANGLE	CASTER ANGLE	TOE
● INITIAL READING			
● FACTORY SPEC			
● FINAL SETTING			

RIGHT FRONT	CAMBER ANGLE	CASTER ANGLE	TOE
● INITIAL READING			
● FACTORY SPEC			
● FINAL SETTING			

TOTAL TOE (FINAL SETTING)

REAR	REAR TOE		REAR CAMBER	
	LEFT	RIGHT	LEFT	RIGHT
● INITIAL READING				
● FACTORY SPEC				
● FINAL SETTING				
● TOTAL TOE (FINAL SETTING)				

THRUST ANGLE	
LEFT	RIGHT
FINAL	

	STEERING AXIS INCLIN	INCLUDED ANGLE	WHEEL SET BACK
LEFT			
RIGHT			
SPEC			

TURNING ANGLE		
R	IN	
	OUT	
L	IN	
	OUT	

● CHECK ALL WHEELS & TIRES . . .

CONDITION	LF	RF	LR	RR
PRESSURE				
RUN OUT				
OUT OF ROUND				
EXCESSIVE WEAR				
BALANCE				

● TORISON-BAR VEHICLES ONLY . . .

SUSPENSION HEIGHT		
	LEFT	RIGHT
INITIAL READINGS		
FACTORY SPECS		
FINAL SETTINGS		

● TRUCKS ONLY . . .

FRAME ANGLE	
LEFT	RIGHT

SUSPENSION HEIGHT	
LEFT	RIGHT

REMARKS ____

HUNTER

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EVALUATOR NOTE

Use the following answer key to check student answers to pretest questions. To determine the students' individual study requirements from the pretest results, use the following table which shows the correlation between the objectives and pretest questions. Then counsel students individually on pretest results and study requirements.

TABLE

Correlation between objectives and pretest questions:

Objective	Question
1	2, 13, 25
2	3, 14
3	36, 37, 38
4	42, 43, 44
5	4, 15, 35, 45
6	46, 47, 48, 49, 50, 51, 52
7	68, 69, 70, 71, 72, 73
8	5, 16
9	76, 77, 78
10	54, 66, 75
11	53, 67, 74
12	31, 79
13	21, 22
14	23, 24
15	64, 65
16A	1, 34, 55
16B	6, 33, 56
16C	7, 32, 57
16D	8, 31, 58
16E	9, 30, 59
16F	10, 29, 60
16G	11, 28, 61
16H	12, 27, 62
16I	17, 26
16J	18, 39, 63
16K	19, 40
16L	20, 41
16M	80, 81

ANSWER KEY

1. C
2. B
3. C
4. B
5. C
6. C
7. D
8. A
9. B
10. C
11. B
12. A
13. C
14. D
15. D
16. D
17. A
18. C
19. A
20. C
21. D
22. B
23. A
24. A
25. B
26. A
27. D
28. C
29. D
30. D
31. D
32. A
33. C
34. D
35. A
36. D
37. B
38. B
39. C
40. B
41. D
42. B
43. A
44. C
45. D
46. B
47. C
48. C
49. A
50. C
51. B
52. A
53. D
54. B
55. A
56. C
57. D
58. D
59. C
60. A
61. C
62. B
63. A
64. A
65. B
66. B
67. B
68. B
69. A
70. B
71. C
72. D
73. D
74. A
75. A
76. C
77. D
78. D
79. B
80. D
81. A

SERVICE STEERING SYSTEMS

NAME ______________________________ SCORE ______

DIRECTIONS

Read the following questions and problems. Select the item that best answers the question or solves the problem and write the correct letter in the blank.

______1. What is the advantage of a collapsible steering column?

A. It is more easily installed in compact cars
B. It allows the driver to adjust the distance between the driver and the steering wheel
C. It absorbs the force of a collision, reducing the driver's risk of injury
D. It allows the driver to tilt the steering wheel to a more comfortable position

______2. Which of the following best defines *pitman arm*?

A. Rod connecting the idler arms to the tie-rods; transfers steering movement from the idler arm to both sides of vehicle
B. Part connecting the steering gear to the center link; transfers the rotating motion of the sector shaft to side-to-side motion at the center link
C. Part of the wheel spindle assembly connecting the ball joints
D. Part connecting the pinion gear and the gear rack

______3. Technician A says that a purpose of the steering system is to allow the driver to position the vehicle's wheels. Technician B says that a purpose of the system is to maintain the correct relationship between the front wheels while the vehicle is moving. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______4. *The angle between vertical and a line running through the centers of the upper and lower pivot points of the steering support when viewed from the side* best describes:

A. Camber
B. Caster
C. Included angle
D. None of the above

______5. Which of the following statements is **not** correct?

A. The power steering pump delivers fluid under pressure to the control valve
B. The reservoir holds power steering fluid and is usually a part of the pump
C. The control valve prevents heat damage to hoses and seals by lowering fluid temperature
D. Hoses carry fluid under pressure between parts of the power steering system

______6. Technician A says that before replacing a pitman arm it should be visually inspected and shaken to check for slack. Technician B says that the center link should be checked for looseness. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______7. Idler arms may be connected to the center link by which of the following?

A. A threaded bushing
B. A rubber torsion bushing
C. A ball and socket
D. All of the above

______8. When replacing a center link, it must be disconnected from all of the following parts **except** the:

A. Steering arm
B. Pitman arm
C. Idler arm
D. Tie rods

______9. Which of the following statements concerning tie-rod assembly service is correct?

A. If one tie-rod end is damaged, bent, or worn, both tie-rod ends must be replaced
B. If one tie-rod end is damaged, bent, or worn, it should be replaced; the adjuster sleeve and the other tie-rod end do not have to be replaced
C. If one tie-rod end is damaged, bent, or worn, both tie-rod ends and the adjuster sleeve must be replaced
D. If a tie-rod end is damaged, bent, or worn, it should be replaced only if it cannot be repaired to manufacturer's specifications

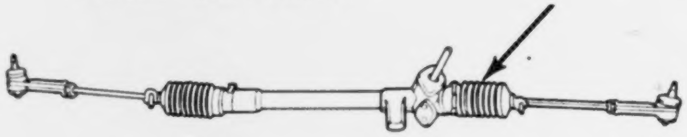
______10. Technicians A, B, and C are discussing steering damper installation. Technician A says that a steering damper can be installed between the pitman arm and the idler arm. Technician B says that it can be installed between the center link and the frame. Technician C says that the damper can be installed between the pitman arm and the center link. Who is correct?

A. Technicians A and C
B. Technicians A and B
C. Technicians B and C
D. Technicians A, B, and C are all correct

_____11. Which of the following statements about adjusting a recirculating-ball type manual steering gear is **not** correct?

A. Wasted motion between the sector gear and the ball nut is called *lash*
B. Sector shaft end play should be adjusted before worm bearing preload is adjusted
C. Adjusting the clearance between the sector shaft and the ball nut is called *sector shaft end play adjustment*
D. Worm bearing preload should be adjusted before sector shaft end play is adjusted

_____12. In the illustration below, what is the name of the part indicated with an arrow?



Used with permission of Chrysler Corp.

A. Bellows boot
B. CV joint
C. Ball joint
D. None of the above

_____13. Which of the following is the best definition of *steering linkage*?

A. System which uses hydraulic pressure from a pump to assist steering wheel turning effort
B. Rod connecting the pitman and idler arms to the tie-rods; transfers steering movement from the pitman arm to both sides of the vehicle
C. Assembly connecting the steering gear and the front wheels; transmits motion from the steering gear to the steering knuckle
D. System in which steering motion is transmitted mechanically with no power assist

_____14. Which of the following is a purpose of the steering system?

A. To transmit the feel of the road surface to the driver
B. To allow the front wheels to turn with reasonable effort
C. To maintain the correct relationship between the front wheels while the vehicle is moving
D. All of the above

_____15. Which of the following best describes *steering axis inclination*?

A. The angle between vertical and a line running though the centers of the upper and lower pivot points of the steering support when viewed from the side
B. The tilt of the top of the tire and wheel assembly inward or outward when compared to a vertical line extending from the center of the bottom of the assembly
C. The difference between the two angles of the front wheels relative to the vehicle when the vehicle is turning
D. The angle between vertical and a line running through the centers of the upper and lower pivot points of the steering support when viewed from the front

_____16. Which of the following statements best describes the function of the *power cylinder*?

A. Holds the power steering fluid; usually is part of the power steering pump
B. Senses the amount of steering effort being applied and opens or closes ports to direct the fluid to the power piston from the pump
C. Regulates the pressure of the fluid in the steering gear
D. Transmits the force of the fluid from the control valve to the steering linkage

_____17. Technicians A and B are discussing manual rack-and-pinion steering systems. Technician A says that out-of-adjustment conditions are more noticeable in a rack-and-pinion system. Technician B says that a faint knocking sound heard when the vehicle is driven over rough roads or turned sharply is an indication that the gear must be replaced. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____18. When performing a power steering pressure test, it is important to do which of the following?

A. Perform the test after the power steering fluid has cooled
B. Hold the steering wheel five minutes at each stop and take a reading
C. Compare the pressure readings to the manufacturer's specifications
D. Both A and C

_____19. Which of the following statements about power recirculating-ball type steering gears is correct?

A. The procedure for sector shaft adjustment is similar to the adjusting procedure on a manual recirculating-ball type steering gear
B. The procedure for worm bearing preload adjustment is the same as the adjusting procedure on a manual recirculating-ball type steering gear
C. Some power recirculating-ball type steering gears do not require the adjustment of sector shaft end play
D. All of the above

_____20. Technician A says if a power rack-and-pinion steering assembly is leaking, the problem might be corrected by replacing worn seals. Technician B says leakage could be a result of excessive pump pressure. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____21. A customer brings a vehicle to your shop and complains that the steering column is difficult to lock. You verify the complaint and find that it will not lock in any tilt position. Which of the following is likely to cause this problem?

A. Shoe seized on its pivot pin
B. Shoe grooves may have burrs or dirt
C. Shoe lock spring is weak or broken
D. All of the above

_____22. The steering wheel on the vehicle you are servicing returns to the center position poorly. What is the **most** likely cause of this condition?

A. Damaged lock bolt
B Misaligned steering column U-joints
C. Weak steering wheel spring
D. Upper bearing not seated in housing

_____23. When you test drive a late model vehicle with manual rack-and-pinion steering, you can feel roughness when turning the steering wheel. What is the **most** likely cause of this condition?

A. Worn pinion shaft bearings
B. Lack of lubrication in the steering linkage
C. Power steering fluid level too low
D. None of the above

_____24. A customer brings in an older model car with a manual recirculating-ball type steering gear to your shop for repair. He complains that there is too much play in the steering wheel. Which of the following could cause this condition?

A. Improperly adjusted gear
B. Bent pitman arm
C. Loose steering column
D. Too much lubricant in the steering gearbox

_____25. *A steering system component designed so that steering wheel motion is transferred to the wheels through a linkage consisting of a pitman arm, idler arm, center link, and tie-rod assemblies* is the definition of which of the following terms?

A. Rack-and-pinion steering design
B. Parallelogram steering design
C. Steering linkage design
D. Manual steering system

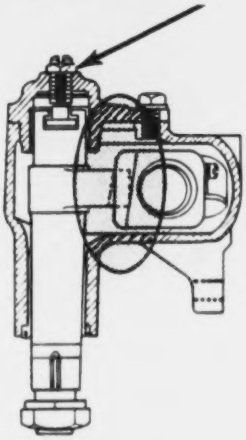
_____26. Which of the following statements about manual rack-and-pinion steering gears is **not** correct?

A. This design has more moving parts than the parallelogram design
B. Design features will affect the removal and installation procedures
C. Noise or roughness in the gear may indicate a need for service
D. Both A and C

_____27. Which of the following statements about bellows boots is correct?

A. They are made of neoprene
B. They should be replaced if damaged
C. They are fastened with clamps
D. All of the above

_____28. In the figure below, what is the purpose of the part indicated by the arrow?



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A. To adjust worm bearing preload
B. To maintain an even pressure on the sector shaft when the vehicle turns
C. To adjust sector shaft end play
D. To secure the steering gear housing

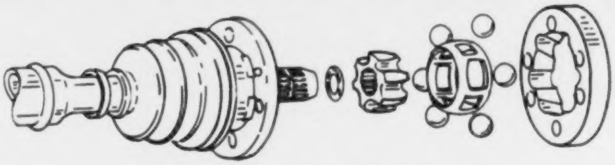
_____29. Which of the following conditions usually requires that the steering damper be replaced?

A. Stain discoloration
B. Uneven tire wear
C. Worn tie-rod mounting
D. None of the above

_____30. Technician A says tie-rods on rack-and-pinion steering linkages have to be replaced in sets. Technician B says rack-and-pinion steering linkages do not have tie-rods. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____31. What type of CV joint is shown below?



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A. Rzeppa fixed joint
B. Tripod joint with closed tulip housing
C. Tripod joint with open tulip housing
D. Rzeppa plunging joint (cross groove joint)

_____32. Which of the following statements about idler arm removal is correct?

A. The idler arm support must be removed when removing an idler arm with a steel bushing
B. The idler arm support must be removed when removing an idler arm with a rubber torsion bushing
C. The idler arm support does not need to be removed when replacing an idler arm with a ball-and-socket joint
D. All of the above

_____33. Technician A says before replacing a pitman arm the center link should be checked to see if it is parallel to the ground. Technician B says this check should be made after the new pitman arm is installed. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

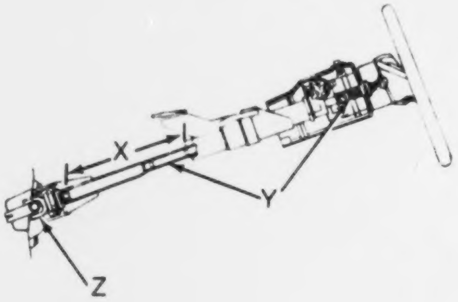
_____34. Steering columns provide routing for control linkages and wiring for which of the following?

A. Hazard signals
B. Cruise control
C. Transmission gear selector
D. All of the above

_____35. Which of the following best describes *included angle*?

- A. The total angle from the inside of the SAI angle to the outside of the camber angle
- B. The angle between vertical and a line running through the centers of the upper and lower pivot points of the steering support when viewed from the front
- C. The difference between the two angles of the front wheels relative to the vehicle when the vehicle is turning
- D. The tilt of the top of the tire and wheel assembly inward or outward when compared to a vertical line extending from the center of the bottom of the assembly

For items 36 through 38, refer to the illustration below.



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_____36. The part labeled X is the:

- A. Dash mount
- B. Steering shaft
- C. Steering wheel
- D. Collapsible section

_____37. The part labeled Y is the:

- A. Dash mount
- B. Steering shaft
- C. Steering wheel
- D. Collapsible section

_____38. Which part is the *universal joint*?

A. Part X
B. Part Z
C. Part Y
D. None of the above

_____39. Technicians A and B are discussing power steering systems. Technician A says difficult steering may be a result of improper power steering pressure. Technician B says it may also be a valve sealing problem within the rack-and-pinion gear. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

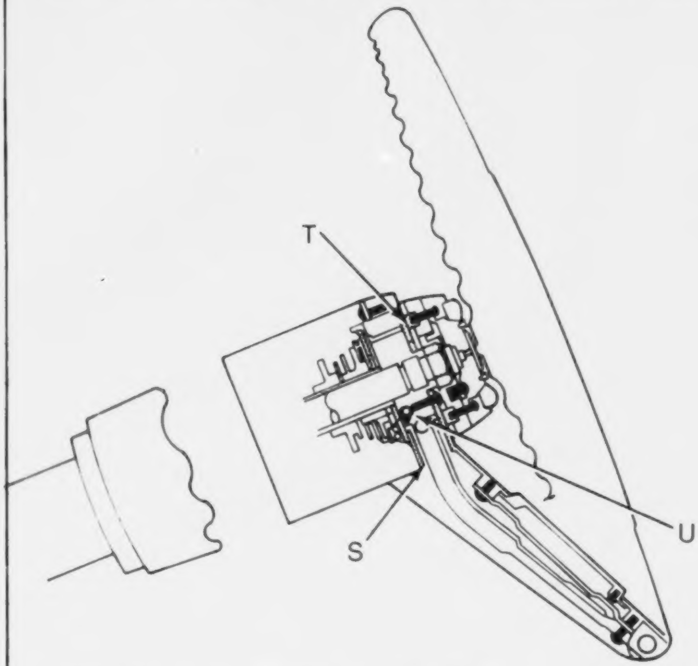
_____40. Which of the following statements about power recirculating-ball type steering gears is correct?

A. If adjustment does not correct the steering gear problem, the gear must be replaced
B. If adjustment does not correct the steering gear problem, the power steering pump should be tested
C. A newly installed steering gear does **not** require adjustment
D. A newly installed steering gear requires sector shaft end play adjustment but does **not** require adjustment of worm bearing preload

_____41. Which of the following statements about power rack-and-pinion steering assemblies is correct?

A. If the steering gear is damaged, the entire assembly must be replaced
B. Leaking seals is a common cause for replacement
C. Leakage can occur if the aluminum housing is badly scored
D. All of the above

For items 42 through 44, refer to the illustration below.



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_____42. The part labeled S is the:

A. Horn ring
B. Lock plate
C. Steering wheel nut
D. None of the above

_____43. The part labeled T is the:

A. Horn ring
B. Lock plate
C. Steering wheel nut
D. Turn signal switch

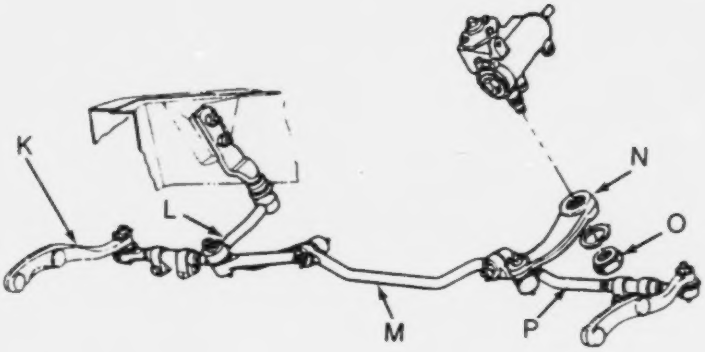
_____44. The part labeled U is the:

A. Horn ring
B. Tilt spring
C. Turn signal switch
D. Steering wheel nut

_____45. *The alignment of the rear wheels with the front wheels* best describes:

A. Camber
B. Turning radius
C. Tow
D. None of the above

For items 46 through 49, refer to the illustration below.



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_____46. Which of the parts is the idler arm?

A. Part K
B. Part L
C. Part M
D. Part N

_____47. What is the name of Part P?

A. Idler arm
B. Pitman arm
C. Tie-rod
D. Adjuster sleeve

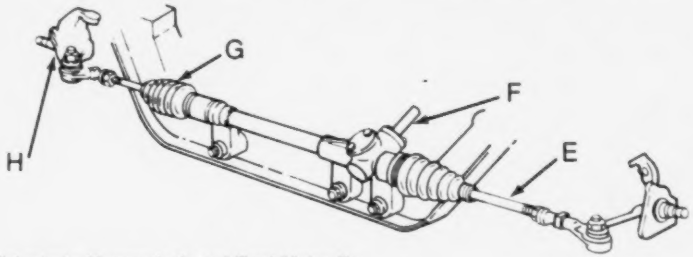
_____48. What is the name of Part M?

A. Steering arm
B. Pitman arm
C. Center link
D. Relay rod

_____49. What is the name of Part K?

A. Steering arm
B. Pitman arm
C. Center link
D. Tie-rod

For items 50 through 52, refer to the illustration below.



Adapted with permission of Ford Motor Co.

_____50. What is the name of Part F?

A. Tie-rod
B. Rack
C. Pinion shaft
D. None of the above

_____51. What is the name of Part G?

A. Steering arm
B. Bellows boot
C. Pinion shaft
D. Steering gear

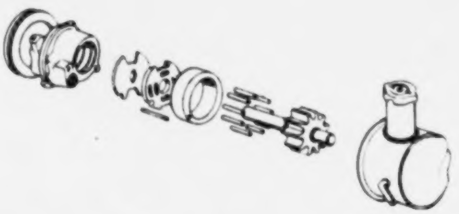
_____52. Which part is the tie-rod?

A. Part E
B. Part F
C. Part G
D. Part H

_____53. Which of the following best describes an *integral* power steering system?

A. System in which a separate power cylinder is attached to the linkage and the control valve is not located within the steering gear housing
B. System in which the control valve is located within the steering gear housing and a separate power cylinder is attached to the linkage
C. System in which the power piston is located within the steering gear housing and the control valve is attached to the steering linkage
D. System in which the power piston and the control valve are located within the steering gear housing

_____54. Technician A says the power steering pump shown below is a vane type pump. Technician B says it is a roller type. Who is correct?



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A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____55. Technicians A and B are discussing steering column service. Technician A says care should be taken when working on an energy-absorbing steering column to avoid collapsing the column. Technician B says no such precautions are necessary because the column will only collapse when the vehicle is involved in a front-end collision. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____56. Which of the following statements is a guideline the technician should follow when replacing a pitman arm?

A. Replace a pitman arm if the socket portion of the connection attached to the center link is badly worn
B. After connecting the pitman arm to the sector shaft, adjust the wheels to the straight ahead position before connecting the center link
C. Always refer to the vehicle manufacturer's service manual for special tools to use
D. None of the above

_____57. Idler arms may be connected to the center link by which of the following?

A. Threaded bushing
B. Rubber torsion bushing
C. Ball and socket
D. All of the above

_____58. Which of the following statements is a guideline to be followed when inspecting and replacing a center link?

A. Use tools specified in the service manual and use them correctly
B. Be sure that studs, holes, and nuts are free from dirt and grease before connecting the center link
C. Choose the replacement center link that meets the manufacturer's specifications
D. All of the above

_____59. Which of the following statements is **not** a guideline that should be followed when replacing tie-rod assemblies?

A. Use an appropriate wrench to hold the rack when unfastening the tie-rod from the rack
B. Always measure the tie-rod assembly before removing any parts of the assembly
C. Be sure that the front end has been aligned before replacing the tie-rod ends
D. Always use new cotter pins to complete fastener installations

_____60. Which of the following statements is **not** a guideline that should be followed when inspecting and replacing a steering damper?

A. Do not attempt to install a steering damper on a vehicle that is not already equipped with one
B. Position the wheels in the straight ahead position when removing a steering damper
C. After installation, turn the wheels from one stop to the other stop to be sure that the damper operates correctly
D. Position the wheels in the straight ahead position when installing a steering damper

_____61. Technicians A and B are discussing recirculating-ball type steering gears. Technician A says problems that appear to be caused by the steering gear can sometimes be corrected by adjusting the worm bearing preload. Technician B says these problems are sometimes corrected by adjusting the sector shaft end play. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____62. Technicians A and B are discussing bellows boots. Technician A says if a boot only has a crack, it doesn't need to be replaced until it splits apart. Technician B says a cracked or split boot should be replaced immediately. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____63. Which of the following statements about power steering pressure testing is **not** correct?

A. Loss of steering pressure indicates that the pump is defective
B. The purpose of the pressure test is to check the operation of pump valves
C. Power steering pumps on different vehicles may vary
D. Power steering pumps on vehicles from the same manufacturer may vary

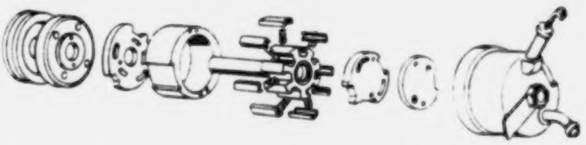
_____64. A customer brings in her car to your shop for repair. The car is equipped with power steering, and she says that it makes a whining noise when she turns the steering wheel. What could cause this problem?

A. Low fluid level
B. Tight drive belt or pulley
C. Both A and B
D. None of the above

_____65. Technician A says excessive steering wheel play can be caused by a problem in the power steering pump. Technician B says the power steering pump could not cause excessive steering wheel play. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____66. Which type of power steering pump is illustrated below?



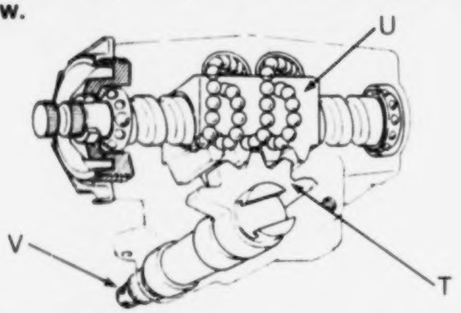
Used with permission of Moog Automotive, Inc

A. Vane
B. Slipper
C. Roller
D. Rotor

_____67. Which of the following best describes a *semi-integral* power steering system?

A. A system in which a separate power cylinder is attached to the linkage and the control valve is not located within the steering gear housing
B. A system in which the control valve is located within the steering gear housing and a separate power cylinder is attached to the linkage
C. A system in which the power piston is located within the steering gear housing and the control valve is attached to the steering linkage
D. A system in which the power piston and the control valve are located within the steering gear housing

For items 68 through 70, refer to the illustration of the steering gear below.



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_____68. What is the name of Part V?

A. Gear sector
B. Sector shaft
C. Pinion shaft
D. Worm shaft

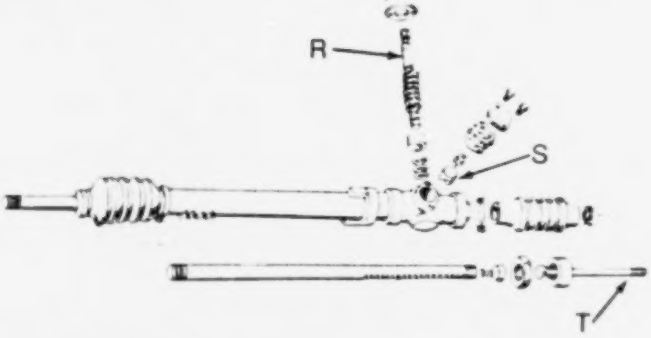
_____69. What is the name of Part U?

A. Ball nut
B. Gear sector
C. Housing
D. Worm

_____70. What is the name of Part T?

A. Bearing
B. Gear sector
C. Ball nut
D. None of the above

For items 71 through 73, refer to the illustration of the steering gear below.



Used with permission of Moog Automotive, Inc.

_____71. What is the name of Part R?

A. Rack
B. Sector shaft
C. Pinion shaft
D. Pinion gear

_____72. What is the name of Part S?

A. Adjuster spring
B. Pinion gear
C. Bearing
D. Support yoke

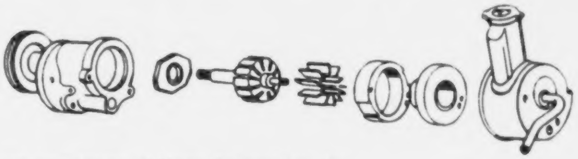
_____73. What is the name of Part T?

A. Rack
B. Sector gear
C. Pitman arm
D. None of the above

_____74. Which of the following best describes a *linkage booster* power steering system?

A. System in which a separate power cylinder is attached to the linkage and the control valve is not located within the steering gear housing
B. System in which the control valve is located within the steering gear housing and a separate power cylinder is attached to the linkage
C. System in which the power piston is located within the steering gear housing and the control valve is attached to the steering linkage
D. System in which the power piston and the control valve are located within the steering gear housing

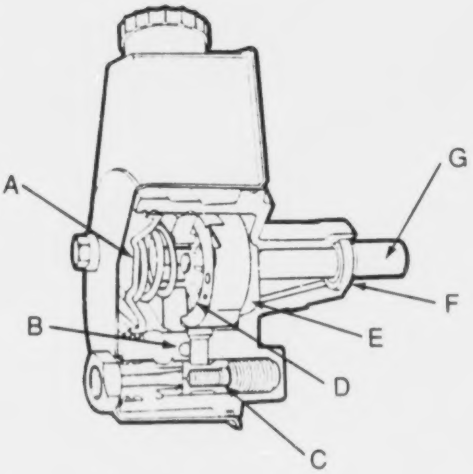
_____75. Which type of power steering pump is illustrated below?



Used with permission of Moog Automotive, Inc.

A. Vane
B. Slipper
C. Roller
D. Rotor

For items 76 through 78, refer to the power steering pump illustrated below.



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_____76. Which part is the *flow control valve*?

- A. Part A
- B. Part B
- C. Part C
- D. Part D

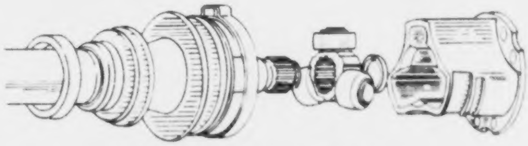
_____77. Which part is the *drive shaft*?

- A. Part D
- B. Part E
- C. Part F
- D. Part G

_____78. What is the name of Part D?

- A. Thrust plate
- B. Pressure plate
- C. End plate
- D. None of the above

_____79. What type of CV joint is shown below?



Used with permission of Dana Corp., Perfect Circle Products

A. Fixed Rzeppa joint
B. Tripod joint with closed tulip housing
C. Tripod joint with open tulip housing
D. Rzeppa plunging joint (cross groove joint)

_____80. Which of the following statements about reconditioning a power steering pump is correct?

A. It is important to use the pulley puller and the seal installer properly
B. Vehicle manufacturers often use more than one model of power steering pump
C. The most common service required is the replacement of seals
D. All of the above

_____81. Which of the following statements about CV joint service is correct?

A. Some CV joints should not be reconditioned, they should be replaced
B. Any type of good quality chassis lubricant can be used when replacing CV joints
C. If the housing is damaged, add new lubricant to the joint and replace the housing
D. Properly support one end of the assembly and allow the end being serviced to hang so that joint can easily be disassembled

OBJECTIVE 1

Select definitions of terms associated with the steering system.

center link — Rod connecting the pitman and idler arms to the tie-rods; transfers steering movement from the pitman arm to both sides of the vehicle

NOTE: The center link is sometimes called the *relay rod.*

constant-velocity (CV) joint — Joint used in a driveline so that output driveshaft speed equals input driveshaft speed

gear ratio — A numerical ratio representing the number of turns made by the drive gear to complete one turn of the driven gear

EXAMPLE: If a driving gear makes five revolutions to turn the driven gear one revolution—the gear ratio is 5:1.

idler arm — Part supporting the end of the center link opposite the pitman arm; keeps the center link parallel to the road surface to maintain proper toe

manual steering system — System in which steering motion is transmitted mechanically with no power assist

parallelogram steering linkage — Steering system components designed so that steering wheel motion is transferred to the wheels through a linkage consisting of a pitman arm, idler arm, center link, and tie-rod assemblies

pitman arm — Part connecting the steering gear to the center link; transfers the rotating motion of the sector shaft to side-to-side motion at the center link

power steering system — System which uses hydraulic pressure from a pump to assist steering wheel turning effort

rack-and-pinion steering linkage — Steering system components designed so that steering wheel motion is transferred to the wheels through a linkage consisting of a pinion gear, rack, and tie-rod assemblies

steering column — Component housing the steering shaft and supporting accessory controls

steering gear — Part of the steering system connecting the steering shaft and the steering linkage; changes rotary motion to side-to-side motion for steering

steering geometry — Various angles formed by the relationship among the suspension system parts, the front wheels, and the ground

NOTE: Front-wheel alignment is achieved by adjusting these different angles to the vehicle manufacturer's specifications.

steering knuckle (arm) — Part of a wheel spindle assembly connecting the ball joints

steering linkage — Assembly connecting the steering gear and the front wheels; transmits motion from the steering gear to the steering knuckle

steering ratio — A numerical ratio representing the number of turns made by the worm shaft to turn the sector shaft once

NOTE: A vehicle with a higher steering ratio is easier to steer than a vehicle with a lower steering ratio. Steering ratios in standard gearboxes normally range from 15:1 to 24:1.

steering shaft — Rod connecting the steering wheel to the steering gear

OBJECTIVE 2

State the purposes of the steering system.

- To allow the driver to position the wheels

  NOTE: The steering system allows the driver to position the vehicle's wheels to control the direction of travel. It also allows the driver to position the wheels for other specific situations such as turning the wheels toward the curb when parking on an incline.

- To allow the turning of the front wheels with reasonable effort
- To maintain the correct relationship between the front wheels while the vehicle is moving
- To transmit the feel of the road surface to the driver

NOTE: Steering system components work closely together with other system components. The relationship of these components varies, depending on the design of each system. The steering system is closely related to the front suspension system and some of the purposes listed here are also purposes of the front suspension system.

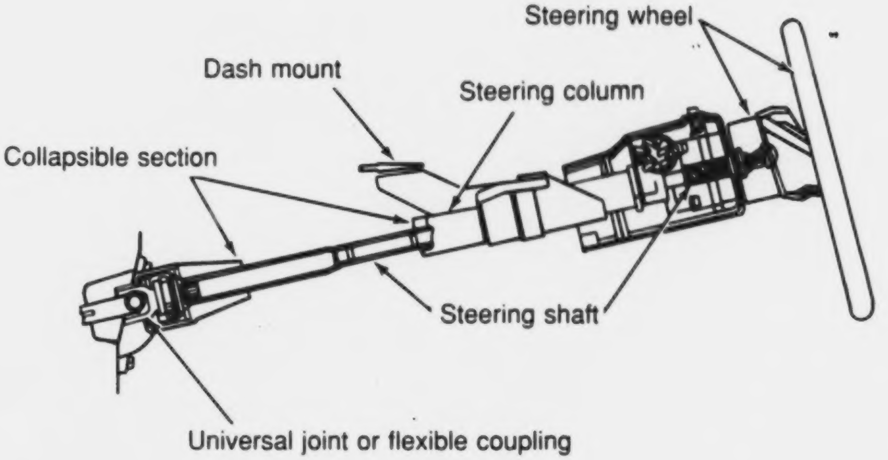
ONE STEP MORE. . .

Consider the many types of steering systems with which you are already familiar. For example, those of bicycles or toy wagons. For a bicycle, the position of the front wheel is directed by simply turning the handlebars which allows the wheel to be pivoted left or right. For a wagon, direction is regulated by the wagon tongue or handle. The two front wagon wheels are connected by a rigid axle that pivots around a central point when the wagon is turned.

Think about these two designs and the steering system found on most motor vehicles. What purposes are shared in the various designs? Why is a motor vehicle steering system different from a bicycle, a wagon, and other steering systems?

OBJECTIVE 3 **Label the parts of a collapsible steering column.**

FIGURE 1



Steering wheel
Dash mount
Steering column
Collapsible section
Steering shaft
Universal joint or flexible coupling

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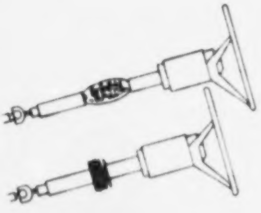
STEERING COLUMNS

Early steering columns on motor vehicles were fairly simple and consisted of a rod that ran from the steering wheel to the steering gearbox. Over the years, automotive designers began to make greater use of the steering column, placing transmission gear shift levers and turn signal levers on the column. Today's steering column is likely to a have a variety of other control mechanisms attached. The steering column is further complicated by convenience features for adjusting the length or angle of the column.

Steering columns also have various built-in safety and security features such as collapsible or locking designs. Some of the more popular designs of collapsing mechanisms are shown below.



Mesh Compresses

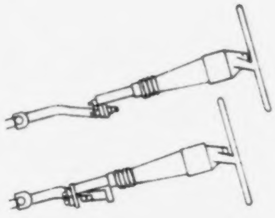
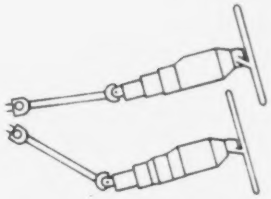


Plate Separates



U-Joints Pivot to
Absorb Crash Impact

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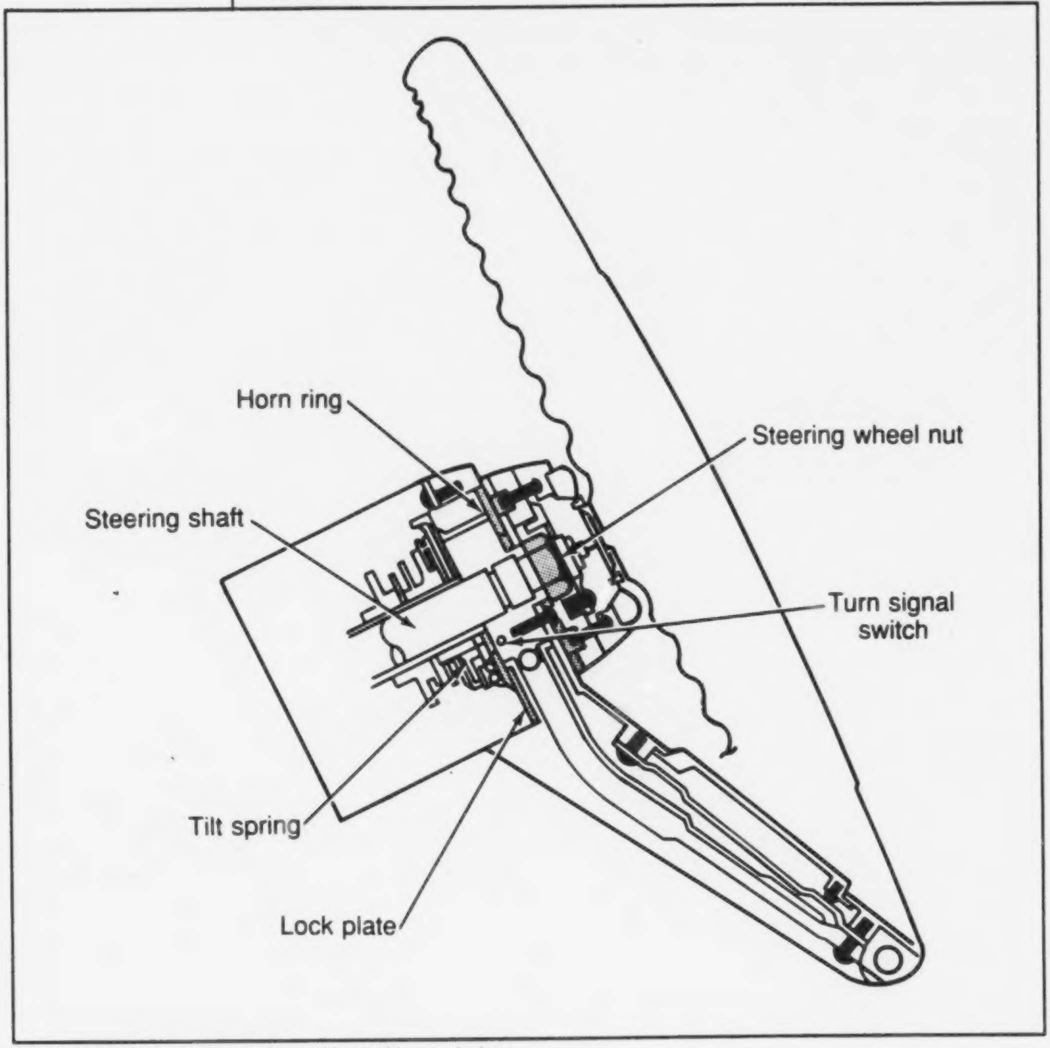
OBJECTIVE 4 **Label the parts of a steering wheel assembly with tilting capabilities.**

FIGURE 2


Horn ring
Steering wheel nut
Steering shaft
Turn signal switch
Tilt spring
Lock plate

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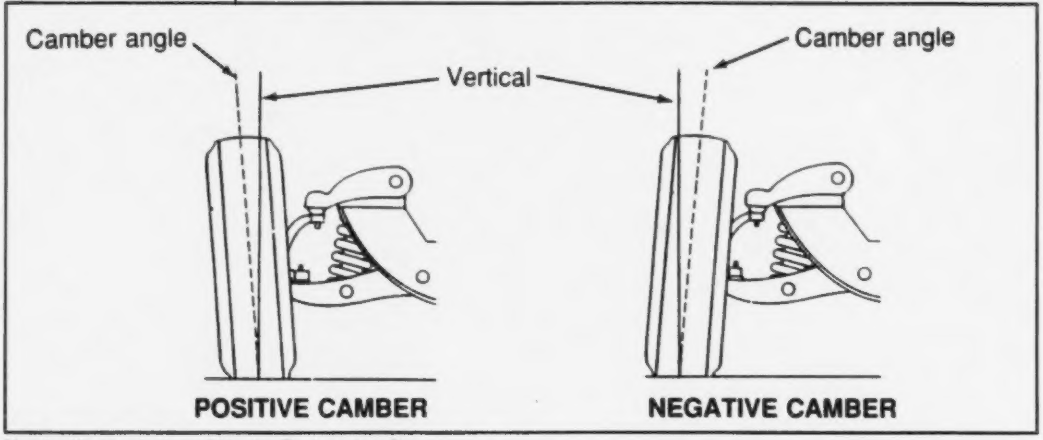
OBJECTIVE 5 **Match the elements of front-end geometry to their descriptions.**

camber — The tilt of the top of the tire and wheel assembly inward or outward when compared to a vertical line extending from the center of the bottom of the assembly (Figure 3)

NOTE: Inward tilt is called *negative camber*, outward tilt is called *positive camber*.

EXAMPLE:

FIGURE 3



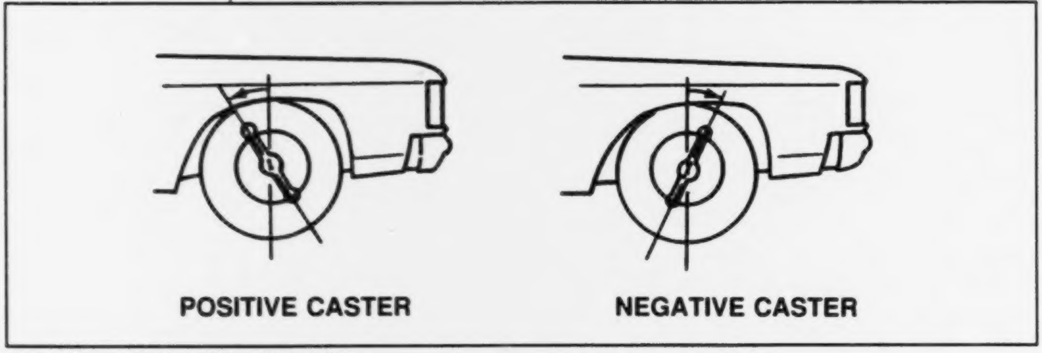
Used with permission of Hunter Engineering Co.

caster — The angle between vertical and a line running through the centers of the upper and lower pivot points of the steering support when viewed from the side (Figure 4)

NOTE: Caster can be negative or positive. If the upper pivot point is rearward of the lower pivot point, the caster is positive. If the upper point is forward of the lower one, the caster is negative.

EXAMPLE:

FIGURE 4


POSITIVE CASTER
NEGATIVE CASTER

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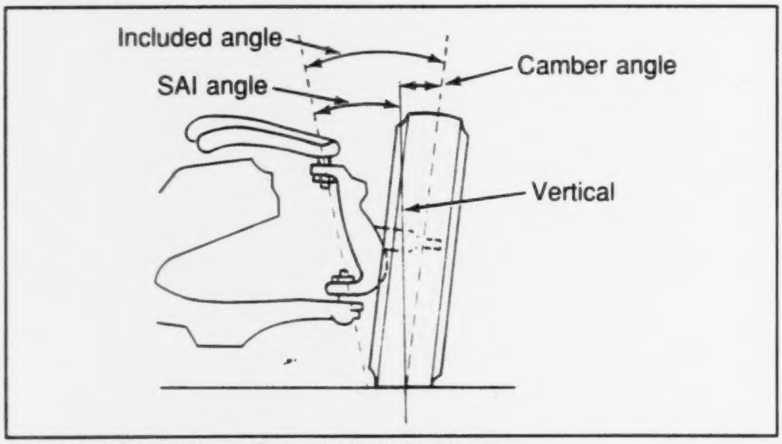
included angle — The total angle from the inside of the SAI angle to the outside of the camber angle (Figure 5)

NOTE: Because most vehicles have positive camber, the included angle is generally the sum of the SAI and the camber.

EXAMPLE:

FIGURE 5


Included angle
SAI angle
Camber angle
Vertical

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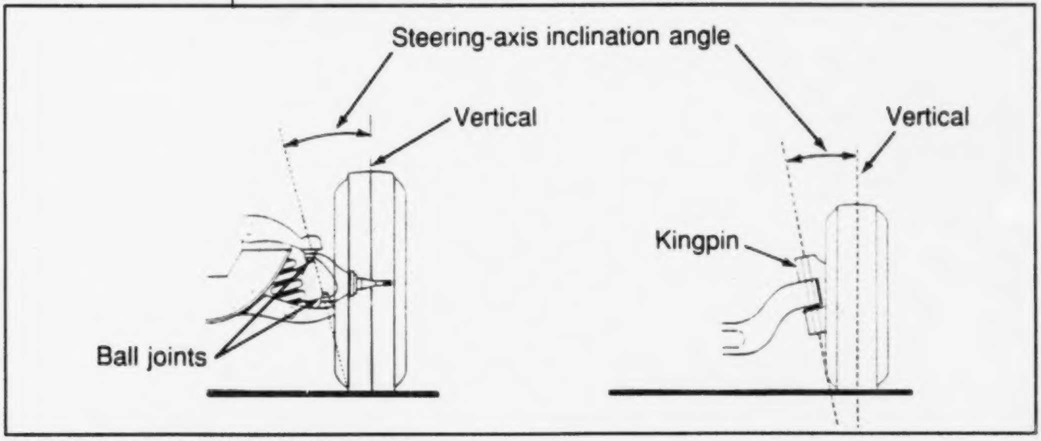
steering axis inclination (SAI) — The angle between vertical and a line running through the centers of the upper and lower pivot points of the steering support when viewed from the front (Figure 6)

NOTE: The front wheels of a vehicle pivot left and right to allow the vehicle to turn. The wheel support normally pivots on ball joints or kingpins. As a result, SAI is sometimes called *ball joint inclination* or *kingpin inclination (KPI)*.

EXAMPLE:

FIGURE 6


Steering-axis inclination angle
Vertical
Vertical
Kingpin
Ball joints

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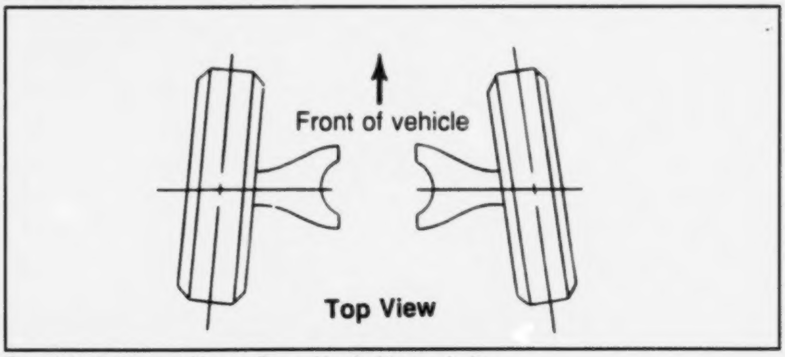
toe — The relationship of the distances between both wheels on an axle measured at both the front and the back of the wheels.

NOTE: *Toe-in* is the term used when the front of the front wheels point together; *toe-out* is the term used when they point away from each other.

EXAMPLE:

FIGURE 7



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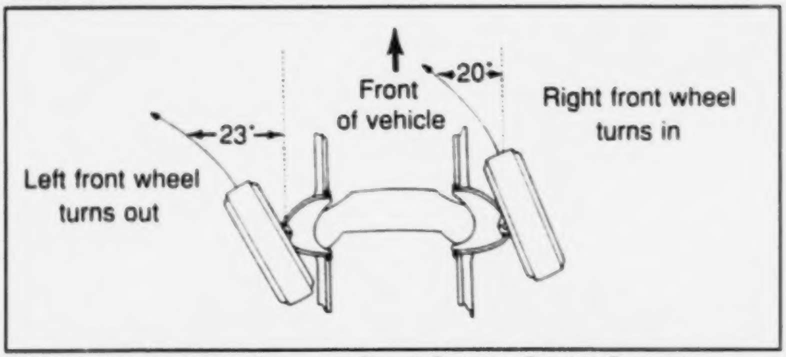
turning radius — The difference between the two angles of the front wheels relative to the vehicle when the vehicle is turning (Figure 8)

NOTE: Turning radius refers to the fact that the outer wheel has to make a circle with a longer radius than the inner wheel when a vehicle turns. To make up this difference in radii, some steering systems are designed to toe-out the outer wheel slightly on a turn as shown in Figure 8.

EXAMPLE:

FIGURE 8


Front
of vehicle
23°
20°
Right front wheel
turns in
Left front wheel
turns out

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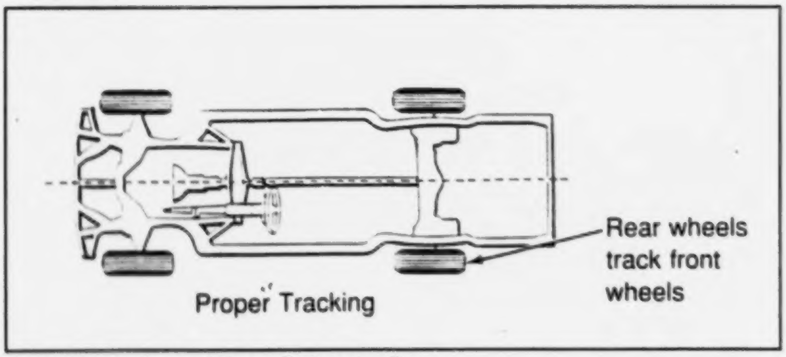
tracking — The alignment of the rear wheels with the front wheels (Figure 9)

EXAMPLE:

FIGURE 9


Rear wheels
track front
wheels
Proper Tracking

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ALIGNMENT

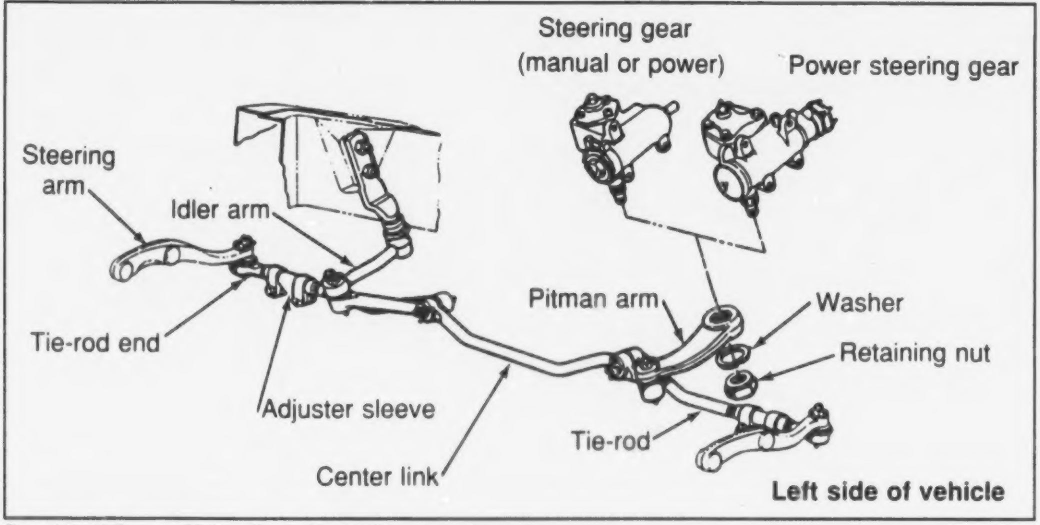
Front-end geometry is important in making sure that the vehicle handles correctly and that the wear of tires and parts is kept to a minimum. However, during driving, the elements of front-end geometry can get out of alignment. This can also happen as parts wear. As a result, the steering and suspension specialist may have to adjust this alignment. Some elements are easily adjustable while others can be adjusted only by replacing or reshaping the parts. Those elements that can be easily adjusted vary from vehicle to vehicle. The manufacturer's service manual should always be consulted for exact specifications, but the guide below will give you some idea of the elements that can be adjusted.

Always adjustable:	Toe
Sometimes adjustable:	Camber, caster, included angle, tracking
Not adjustable:	SAI, turning radius

OBJECTIVE 6 **Label the parts of steering linkage designs.**

Parallelogram linkage (Figure 10)

FIGURE 10


Steering gear
(manual or power)
Power steering gear
Steering arm
Idler arm
Pitman arm
Washer
Retaining nut
Tie-rod end
Adjuster sleeve
Tie-rod
Center link
Left side of vehicle

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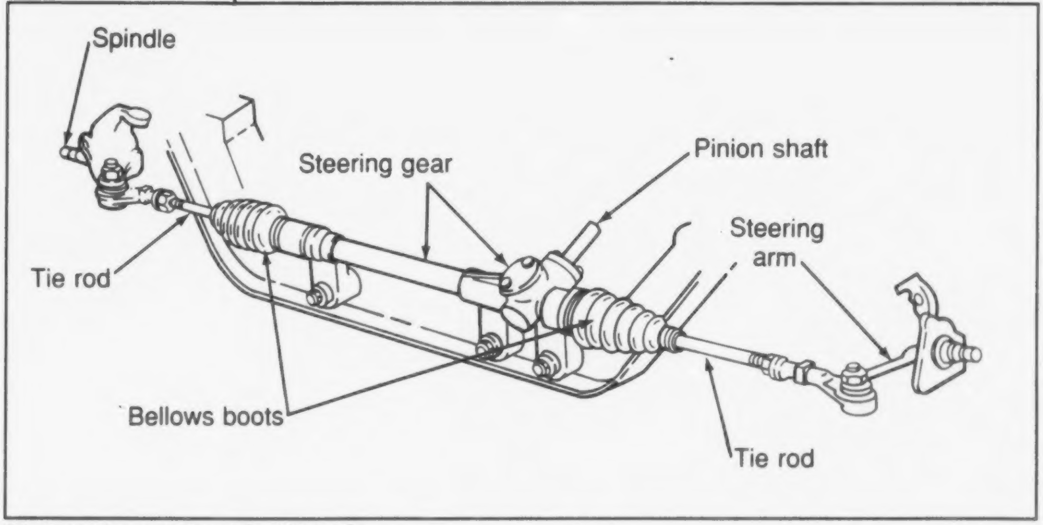
Rack-and-pinion linkage (Figure 11)

FIGURE 11


Spindle
Pinion shaft
Steering gear
Steering arm
Tie rod
Bellows boots
Tie rod

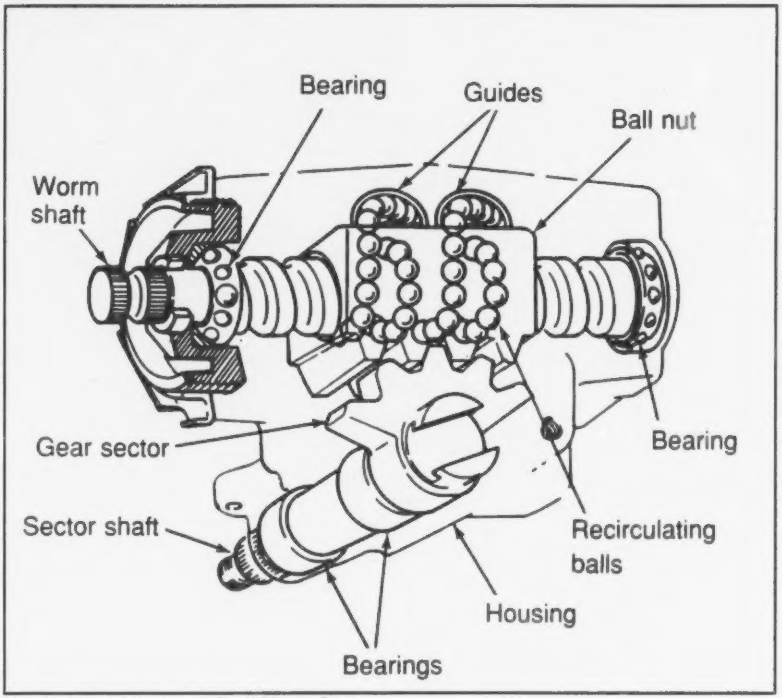
Adapted with permission of Ford Motor Co.

OBJECTIVE 7

Label the parts of steering gears.

Recirculating-ball type (Figure 12)

FIGURE 12


Bearing
Guides
Ball nut
Worm shaft
Gear sector
Bearing
Sector shaft
Recirculating balls
Housing
Bearings

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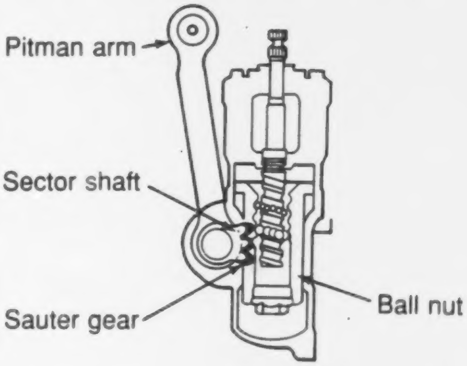
STEERING GEAR OPERATION

The two basic types of steering gears are the recirculating-ball and the rack-and-pinion. Either may be manual or power-assisted, however, both types have a major purpose in common: to transfer the movement of the steering wheel to the wheels.

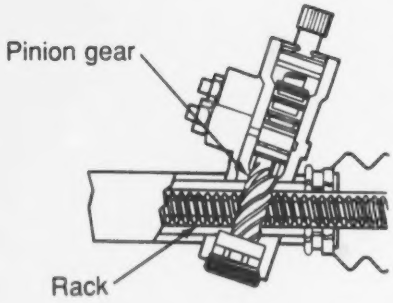
Steering systems with the recirculating-ball type steering gear were designed for larger cars. The additional levers and rods make turning easier. The rack-and-pinion gear was designed for vehicles with limited space. It also provides the driver with a better feel of the road. Rack-and-pinion steering gears are more costly to repair because the entire assembly must be replaced if any part is worn or defective.

In the recirculating-ball type steering gear, steering wheel movement causes a ball nut to move up or down the worm shaft. The gear teeth of the ball nut mesh with the teeth of the sector shaft gear, rotating the sector shaft. This movement is then transmitted to the pitman arm, through the steering linkage, and on to the wheels.

In the rack-and-pinion design, the pinion gear is connected to the lower end of the steering shaft; when the steering wheel turns, the pinion gear turns. The teeth of the pinion gear and the rack mesh, and the turning pinion gear causes the rack to move. The movement of the rack is then transmitted to the wheels.



Recirculating ball

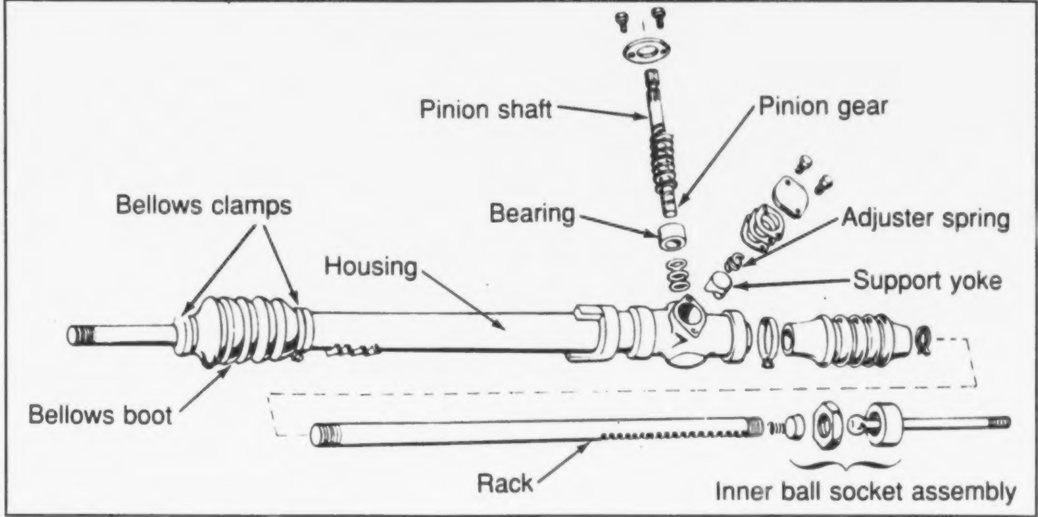


Rack-and-pinion

Used with permission of Chrysler Corp.

Rack-and-pinion type (Figure 13)

FIGURE 13


Pinion shaft
Pinion gear
Bellows clamps
Bearing
Adjuster spring
Housing
Support yoke
Bellows boot
Rack
Inner ball socket assembly

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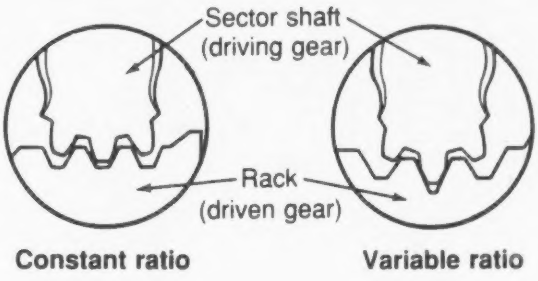
STEERING GEAR RATIO

There are two types of gear ratios. In a steering gear with *constant ratio*, the gear ratio always remains the same. With *variable ratio*, the gear ratio changes—usually from approximately 16:1 with the sector gear centered to approximately 13:1 at the extreme left and right steering wheel positions. This allows the driver better control for straight driving and gradual turns. For sharper turns, as when parallel parking, the lower gear ratio moves the steering gear faster with less effort. These two gear types are shown below.


Sector shaft
(driving gear)
Rack
(driven gear)
Constant ratio
Variable ratio

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The primary difference between constant and variable ratio designs is the length of the middle tooth on the sector shaft and the depth of the slots on the nut or rack piston. By having sector gear teeth of different lengths, the gear ratio between the steering wheel and the sector gear changes.

OBJECTIVE 8 **Match power steering system components to their functions.**

control valve — Senses the amount of steering effort being applied and opens or closes ports to direct the fluid to the power piston from the pump

NOTE: This valve could be either a spool or a rotary valve.

fluid cooler — Prevents heat damage to hoses and seals by lowering the fluid temperature in air-conditioned vehicles

NOTE: This component is only found as part of the power steering system of some air-conditioned vehicles. Vehicles with air- conditioning usually have higher temperatures under the hood than vehicles without air-conditioning.

hoses — Carries the fluid (under pressure) between the parts of the power steering system

power cylinder — Transmits the force of the fluid from the control valve to the steering linkage

power steering fluid — Transmits force from the pump to the steering linkage

power steering pump — Delivers fluid under pressure to the control valve

NOTE: There are four basic types of power steering pumps: vane, slipper, roller, and rotor. The major difference in these types is the way the power steering fluid is displaced.

reservoir — Holds the power steering fluid; usually is part of the power steering pump

POWER STEERING FLUID

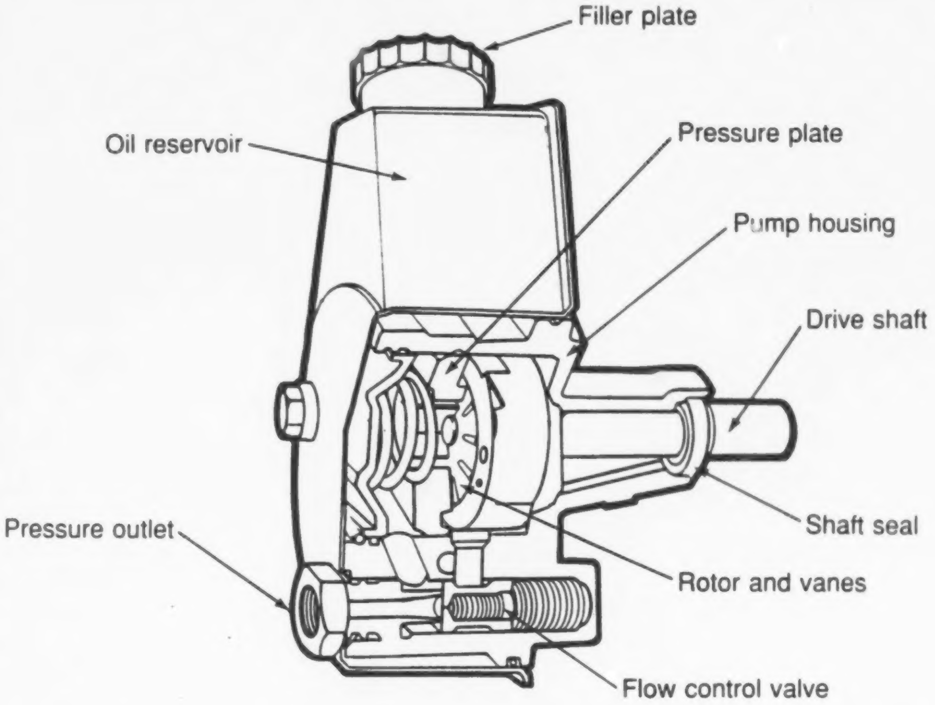
The fluid in the power steering system transmits hydraulic pressure from the pump to the steering linkage. Without this fluid the power-assist system would not operate.

Although in the past automatic transmission fluid was often used in the power steering system, it is not now considered a wise practice to do so. Manufacturers currently recommend that only power steering fluid be used. In fact, automatic transmission fluid can cause the power steering unit to operate improperly.

Power steering fluid is designed especially for power steering systems. It is noncorrosive and withstands extreme temperature variations. It often contains additives such as detergents or stabilizers to help keep the system clean and reduce wear on the parts.

OBJECTIVE 9 **Label the parts of a power steering pump.**

FIGURE 14


Filler plate
Oil reservoir
Pressure plate
Pump housing
Drive shaft
Shaft seal
Pressure outlet
Rotor and vanes
Flow control valve

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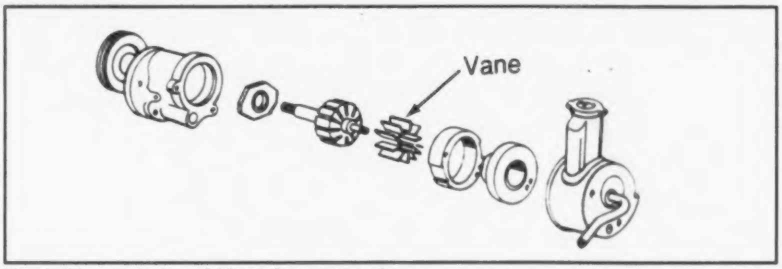
POWER STEERING OPERATION

Power-assisted steering systems use hydraulic fluid, a pump, and valves to make the turning of the wheels easier for the driver. Hydraulic fluid is pressurized in the system by a pump, which is generally driven by a belt run off the engine. Three valves are used to control the fluid in most designs. A *flow control valve* regulates the pressure of the fluid coming from the power steering pump. The *pressure relief valve* is usually built into the flow control valve and opens if fluid pressure builds beyond the pump's pressure capacity. The third valve is the *directional control valve*, which is usually a spool valve in most systems. The directional control valve is controlled by the steering wheel, pressure on the tire and wheel assemblies, and the piston. The directional control valve shifts flow from one side of the piston to the other to control steering. It also controls the amount of fluid that returns to the reservoir.

OBJECTIVE 10 **Identify types of power steering pumps.**

Vane (Figure 15)

FIGURE 15



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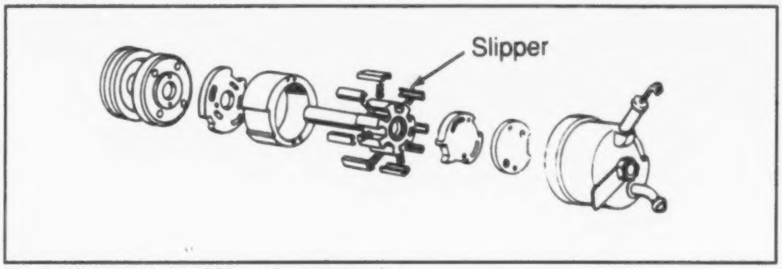
Slipper (Figure 16)

FIGURE 16



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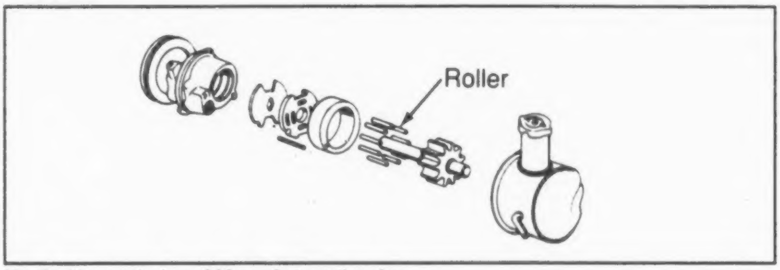
Roller (Figure 17)

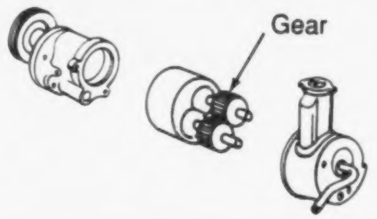
FIGURE 17



Used with permission of Moog Automotive, Inc.

Rotor (gear) (Figure 18)

FIGURE 18



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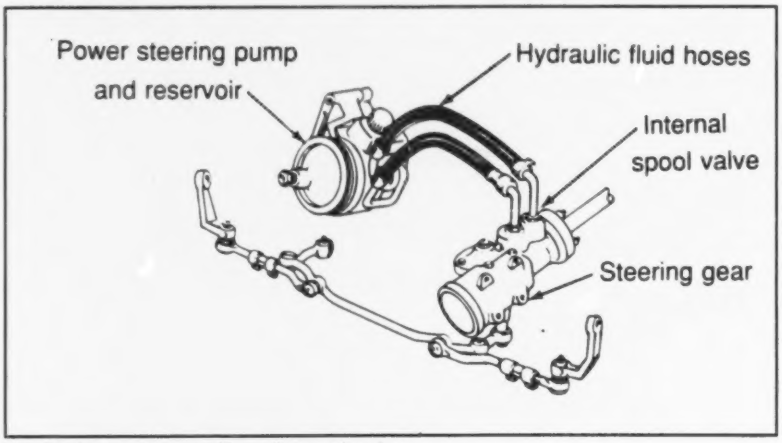
OBJECTIVE 11 **Describe types of power steering systems.**

Integral — System in which the power piston and the control valve are located within the steering gear housing (Figure 19)

NOTE: All rack-and-pinion power steering systems are integral systems.

EXAMPLE:

FIGURE 19


Power steering pump
and reservoir
Hydraulic fluid hoses
Internal
spool valve
Steering gear

Used with permission of Moog Automotive, Inc.

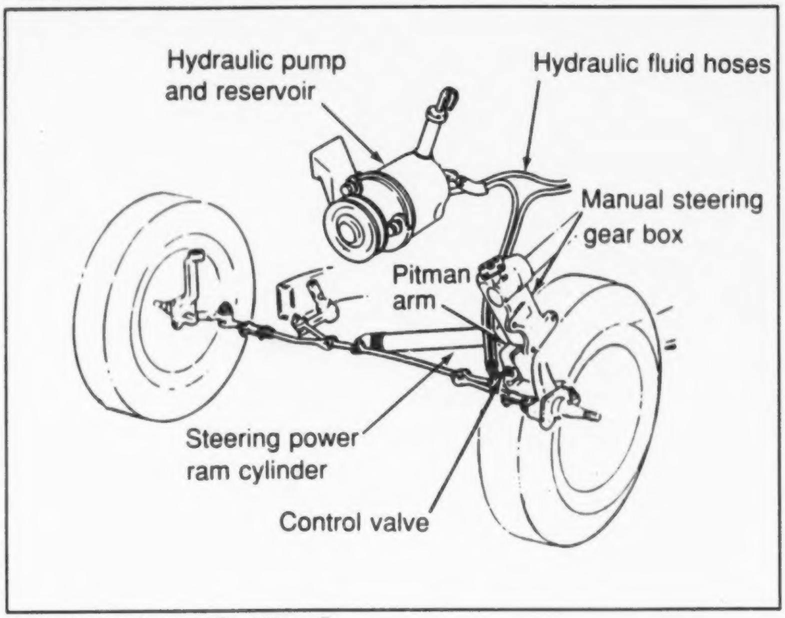
NOTE: Some older vehicles have a *semi-integral* power steering system in which the control valve is located within the steering gear housing and a separate power cylinder is attached to the linkage.

Linkage booster — System in which a separate power cylinder is attached to the linkage and the control valve is not located within the steering gear housing (Figure 20)

NOTE: In a linkage booster system, the control valve may be part of the power cylinder that is attached to the linkage.

EXAMPLE:

FIGURE 20


Hydraulic pump
and reservoir
Hydraulic fluid hoses
Manual steering
gear box
Pitman
arm
Steering power
ram cylinder
Control valve

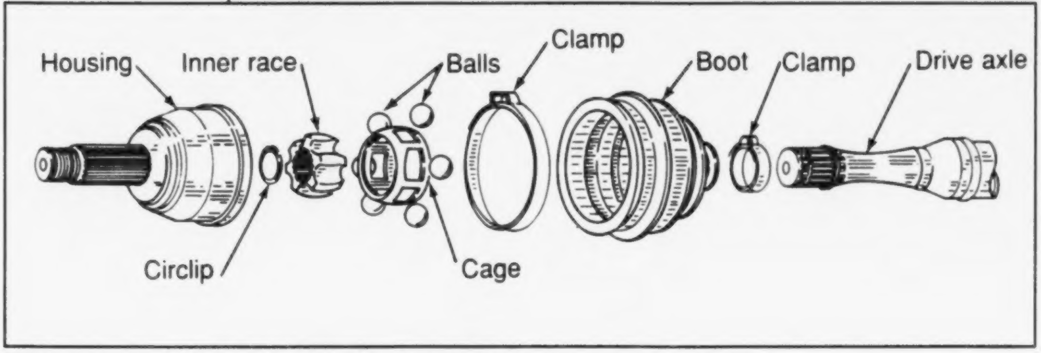
Used with permission of Ford Motor Co.

OBJECTIVE 12 **Identify types of constant-velocity joints.**

Fixed Rzeppa joint (Figure 21)

NOTE: This type of CV joint is a non-plunging type that is **not** designed to move in and out. It is usually used as the outside joint on the half shaft. (Rzeppa is pronounced *Sheppa.*)

FIGURE 21

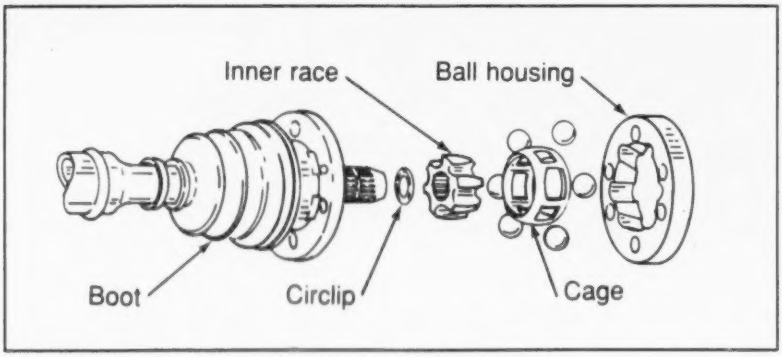

Housing
Inner race
Balls
Clamp
Boot
Clamp
Drive axle
Circlip
Cage

Used with permission of Dana Corp., Perfect Circle Products.

NOTE: The following three types of CV joints (Figures 22-24) are plunging types that are designed to move in and out. They are used as the inside joint on the half shaft and allow the shaft to change length to compensate for the up-and-down movement of suspension.

Rzeppa plunging joint (cross groove joint) (Figure 22)

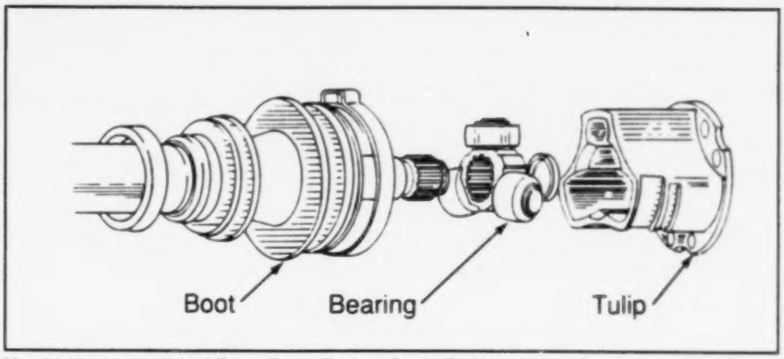
FIGURE 22


Inner race
Ball housing
Boot
Circlip
Cage

Used with permission of Dana Corp., Perfect Circle Products.

Tripod joint (with closed tulip housing) (Figure 23)

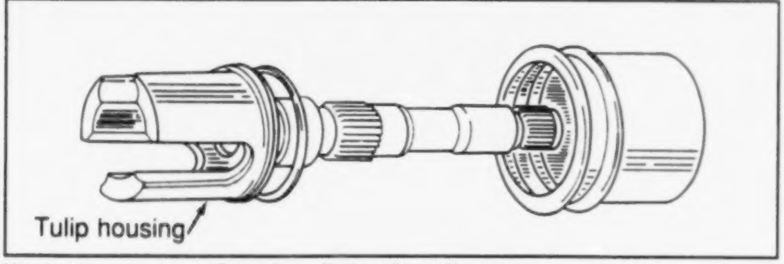
FIGURE 23


Boot
Bearing
Tulip

Used with permission of Dana Corp. Perfect Circle Products.

Tripod joint (with open tulip housing) (Figure 24)

FIGURE 24


Tulip housing

Used with permission of Dana Corp. Perfect Circle Products.

STEERING COLUMN DIAGNOSTIC CHART

This supplement lists some of the common problems associated with the steering column. The information presented in this chart is **not** inclusive. Problems in other systems can also cause some of the conditions listed below. This supplement should be used only as a general guide in diagnosing steering column problems. The correct service manual for the vehicle needing repair should always be consulted for more specific information on diagnosis and repair.

CONDITION	PROBABLE CAUSE
Poor return of steering wheel to center	Steering column U-joints misaligned
Loose steering wheel	Excessive clearance between holes in support or housing and pivot pin diameters Defective or missing anti-lash spring in spheres Upper bearing not seated in housing Upper bearing inner race seal missing Loose support screws Bearing preload spring missing or broken
Loose steering wheel (every other tilt position)	Loose fit between shoe and shoe pivot pin Shoe not free in slot

STEERING COLUMN DIAGNOSTIC CHART (CONT.)

CONDITION	PROBABLE CAUSE
Steering column not locking in any tilt position	Shoe seized on its pivot pin Shoe grooves may have burrs or dirt Shoe lock spring weak or broken
Steering wheel fails to return to top-tilt position	Pivot pins are bound up Wheel tilt spring is broken or weak Turn signal switch wires too tight
Noise in column	Column to steering gear joints loose Column not correctly aligned Horn contact ring not lubricated Lack of grease on bearings Loose sight shields Lower or upper steering shaft bearing worn or broken Shaft lock snap ring not seated Spherical joint not lubricated
Noise when tilting column	Upper tilt bumpers worn Tilt spring rubbing in housing

STEERING COLUMN DIAGNOSTIC CHART (CONT.)

CONDITION	PROBABLE CAUSE
High steering shaft effort	Column assembly misaligned
	Improperly installed or deformed dust seal
	Damaged upper or lower steering shaft bearing
	Flash on I.D. of shift tube
	Tight intermediate steering shaft universal joint
High shift effort (automatic with column shift)	Column not aligned correctly in car
	Wave washer with burrs
	Improperly installed dust seal
	Lack of grease on seal or bearing
	Burr on upper or lower end of shift tube
	Lower bowl bearing not assembled correctly
Column will not unlock	Shear flange on sector shaft collapsed
	Damaged lock bolt, lock cylinder, housing, sector, rack, or park lock cable

STEERING COLUMN DIAGNOSTIC CHART (CONT.)

CONDITION	PROBABLE CAUSE
Column will not lock	Lock bolt spring broken or worn Damaged sector, lock, cylinder, rack, housing Burr on lock bolt Improper shift linkage adjustment Interference between bowl and rack coupling Ignition switch stuck Actuator rod restricted Sector installed incorrectly Park lock cable damaged
Turn signal difficult to operate	Turn signal switch arm loose Yoke broken or distorted; replace switch Loose or misplaced springs Foreign parts and/or material Loose turn signal switch mounting screws

DIAGNOSTIC CHART FOR STEERING SYSTEMS

Proper operation of the steering system is essential to safe and proper performance of the vehicle. Because of this, accurate diagnosis of steering system problems is a very important part of steering system service.

To diagnose steering system problems, the technician should always test drive the vehicle to confirm the customer's complaint and see if other problems are apparent. Then the technician should refer to the appropriate diagnostic chart or troubleshooting guide and make a series of checks. Once the problem has been correctly diagnosed, the specialist can make the necessary repairs to the steering system.

If the vehicle is equipped with power steering, the specialist must determine if the problem is pump-related, gear-related, or linkage-related. This is important because often the same condition can be the result of more than one problem within the steering system.

If the problem appears to be related to the operation of the power steering pump, the specialist should make some initial checks before consulting the appropriate troubleshooting chart. The following checks should be made in the order given:

1. Check the level of the power steering fluid. If it is above or below the recommended level, adjust the fluid level accordingly.

2. Check the belt tension. If it seems to be loose, tighten it. Check the condition of the belt to see if it is frayed or appears to be worn in any way.

3. Check for fluid leaks. Check all hose connections to be sure they are secure. Refer to the appropriate service manual to identify areas where leakage may occur.

4. Turn on the engine and check for excessive or unusual noise from the pump. Do this by listening for noise while turning the steering wheel from stop to stop. However, do not hold the steering wheel at either stop for very long, because this could cause damage.

If the system is a manual steering system, there could be a problem with either the steering gear or the steering linkage. The technician should raise the vehicle and turn the steering wheel from stop to stop to check for hard steering, to see if the gear seems to bind, and to test linkage operation.

This supplement lists some of the more common steering system problems, their causes, and the necessary corrective action. Problems with other systems can also cause some of the following conditions. For instance, some of the conditions listed may be caused by suspension problems, improper tire inflation, or incorrect front wheel alignment. Additionally, there may be other causes for a particular problem, and the needed corrective action will depend on the particular make and model of the vehicle. Use this supplement only as a guide to help you diagnose manual steering gear problems.

CONDITION	PROBABLE CAUSE	CORRECTIVE ACTION
Excessive steering wheel play	Gear improperly adjusted	Adjust gear to specifications
	Worn ball joints in steering linkage	Replace components containing worn ball joints
	Loose tie-rod ends	Adjust tie-rod ends to specifications
	Loose steering gear mounting	Tighten to specifications
Hard steering	Insufficient or improper lubricant in gearbox	Flush, if necessary, and fill with recommended lubricant
	Gear improperly adjusted	Adjust to specifications
	Loose steering gear mounting	Tighten to specifications
	Loose drive belt	Adjust belt
	Low fluid level	Fill to proper level
	Pump binding due to improper fluid or fluid level	Flush, if necessary, and fill with recommended fluid to proper level

DIAGNOSTIC CHART FOR STEERING SYSTEMS (CONT.)

CONDITION	PROBABLE CAUSE	CORRECTIVE ACTION
Steering wheel roughness	Worn wormshaft (recirculating-ball gear) or pinion shaft (rack-and-pinion gear)ball bearings or bearing races	Replace bearing assemblies
Fluid leaks	Loose hose connections	Tighten connections
	Damaged hose	Replace hose
	Too much fluid in reservoir	Adjust to proper level
	Leaking pump, defective seals	Repair or replace pump if necessary or replace seals
Noisy pump	Low oil level	Fill to proper level
	Loose drive belt or pulley	Adjust or replace
	Defective pump	Test pump; repair or replace if necessary
Poor steering return (manual)	Tight steering linkage	Replace defective parts
	Defective steering gear	Repair or replace gear if necessary
	Improper or insufficient lubrication in gearbox	Flush, if necessary, and fill with recommended lubricant
Poor returnability (power)	Insufficient or improper lubrication in steering gear	Flush, if necessary, and fill with recommended lubricant
	Lack of lubrication in steering linkages	Lubricate and/or replace according to manufacturer's instructions
	Improperly adjusted steering gear	Adjust to specifications
	Sticking control valve	Repair or replace valve or gear as necessary

DIAGNOSTIC CHART FOR STEERING SYSTEMS (CONT.)

CONDITION	PROBABLE CAUSE	CORRECTIVE ACTION
Wander	Improper gear adjustment	Adjust to specifications
	Steering wheel not centered on shaft	Re-center steering wheel
	Loose gear mountings	Tighten mountings to specifications
	Loose steering linkage mounting	Tighten mountings to specifications

ACTIVITY SHEET 1

SERVICE STEERING SYSTEMS

II

NAME ______________________________ SCORE ______

ANSWER GENERAL QUESTIONS ABOUT STEERING SYSTEMS

INTRODUCTION

To become certified as a steering and suspension specialist, you must pass a test on steering and suspension systems compiled by the National Institute for Automotive Service Excellence. The certification test covers all aspects of the vehicle's steering and suspension systems. This activity sheet covers only steering systems, but it contains questions similar in content and style to those found on the actual ASE certification test.

DIRECTIONS

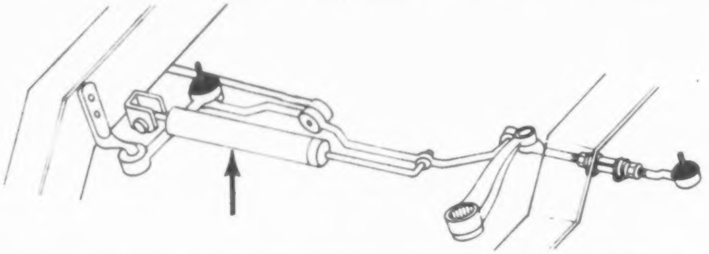
Read each of the following study questions twice. The second time you may notice a key word that you overlooked the first time. Every word in a question is important and may provide a clue to the right answer. Select the answer that is **most** correct and write its letter in the answer blank.

After you have completed this activity sheet, get together with a group of your classmates and use the answer key to check your answers. Discuss the questions and their correct answers, paying particular attention to those that were answered incorrectly. Review any information that you do not understand.

______1. Technician A says the idler arm is connected to the idler arm support and the pitman arm. Technician B says the idler arm is connected to the idler arm support and the left tie rod. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_______2. Refer to the illustration of the steering linkage illustrated below. To which component is the arrow pointing?



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A. Pitman arm
B. Power cylinder
C. Tie rod
D. Steering damper

_______3. Which of the following statements is **not** a guideline that should be followed when working on a steering column?

A. Do not use substitute fasteners that do not meet manufacturer's specifications
B. Repair defective steering column parts then lubricate all moving parts according to manufacturer's instructions
C. Use any special tools recommended by the vehicle manufacturer
D. Refer to the appropriate service manual when inspecting and replacing steering column components

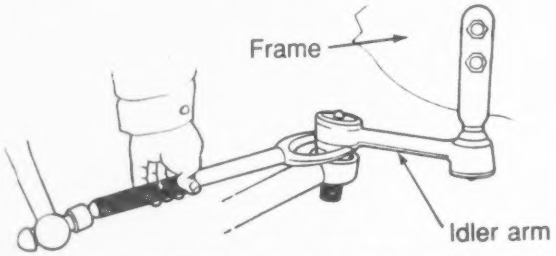
_______4. Technicians A and B are inspecting a vehicle's tie-rod assemblies. Technician A says since the tie-rod ends can be moved up and down, they must be replaced. Technician B says up-and-down movement is normal and the tie-rod ends do not need to be replaced. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______5. Which of the following statements about replacing a pitman arm is **not** correct?

A. Check to be sure the wheels and steering wheel are aligned straight
B. Align the pitman arm with the connecting center link, being careful to align the splines correctly
C. Tighten the retaining nuts to specifications
D. Check the completed installation for looseness

______6. What is the technician doing in the illustration below?



From *Steering, Suspension, and Wheel Service, Unit 2*, © 1980 by State of Florida Department of State. Used with permission of Florida Department of State.

A. Using a bushing remover to remove an idler arm with a threaded bushing
B. Using a tie-rod end fork to remove an idler arm from the center link
C. Using a tie-rod end fork to remove the rubber torsion bushing from the idler arm
D. None of the above

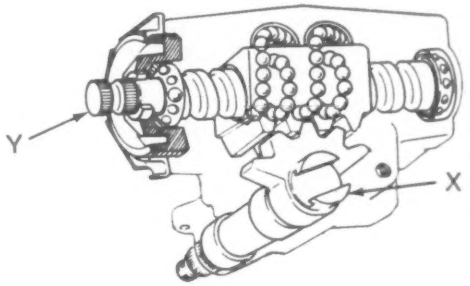
______7. When replacing tie-rod assemblies, the technician should install them so that the toe setting is approximately correct. What should the technician do to ensure this setting?

A. Measure the tie-rod assembly from the center link to the steering arm before disassembly
B. Measure the tie-rod assembly from the center link to the steering arm after installing the tie-rod ends
C. Adjust the tie-rod ends to match the first measurement
D. All of the above

______8. Which of the following tools should be used to disconnect the tie-rod ends from the center link?

A. Hammer and punch
B. Tie-rod end puller
C. Either A or B
D. None of the above

______9. Technicians A and B are discussing steering-gear adjustment. Technician A says the worm bearing preload is adjusted at point X in the illustration below. Technician B says sector shaft lash is adjusted at point Y. Who is correct?



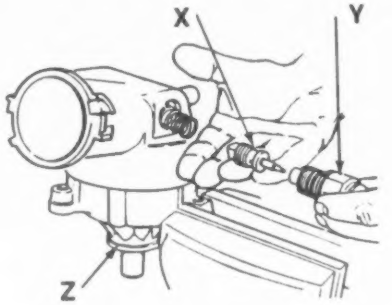
Used with permission of Ford Motor Co.

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______10. The sector shaft is also called the:

A. Pitman shaft
B. Worm shaft
C. Ball shaft
D. All of the above

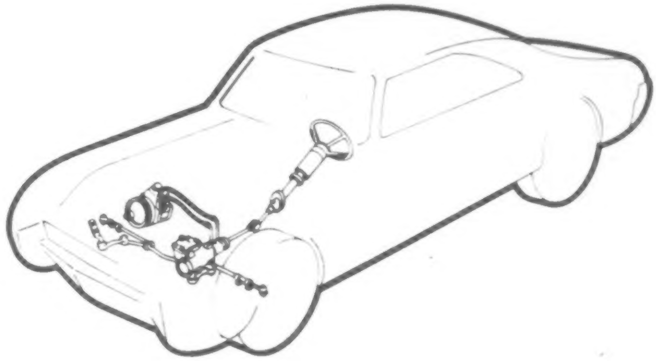
_____11. In the following illustration of a power steering pump and its parts, which part is the flow control valve?



Used with permission of Ford Motor Co.

A. Part X
B. Part Y
C. Part Z
D. None of the above

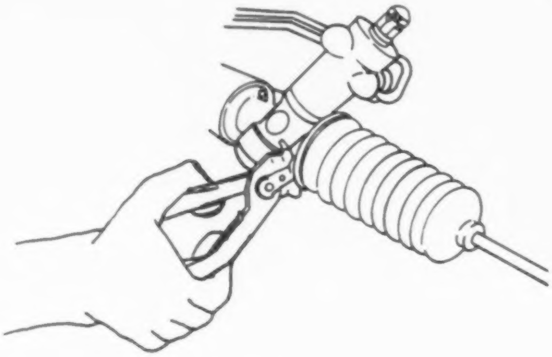
_____12. Technician A says the power steering system illustrated below is a linkage booster system. Technician B says it is an integral system. Who is correct?



Used with permission of Moog Automotive, Inc.

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

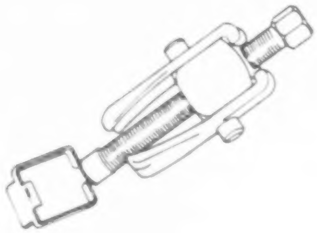
_____13. What is the technician doing in the illustration below?



Used with permission of Chrysler Corp.

A. Removing a CV joint boot
B. Adjusting the steering gear
C. Completing a bellows boot installation
D. None of the above

_____14. Technicians A and B are discussing specialty tools used for steering system service. Technician A says the tool illustrated below is a pitman arm puller. Technician B says the tool can be used to remove the pitman arm but that the tool is called a pulley remover. Who is correct?



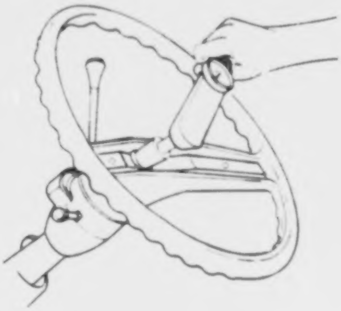
Used with permission of Chrysler Corp.

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____15. Technician A says that a rattling noise which seems to come from the steering gear could be caused by a loose rack adjustment. Technician B says a loose power steering pump belt could be the cause of the noise. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____16. What is the technician doing in the illustration below?



Used with permission of Ford Motor Co.

A. Removing the steering wheel horn plate
B. Installing the steering wheel
C. Measuring the worm shaft preload
D. Tightening the steering wheel lock plate

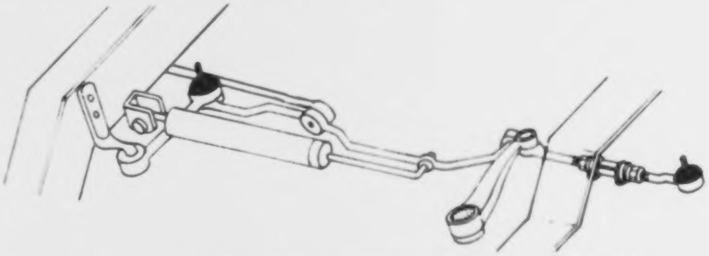
_____17. Technicians A and B are discussing rack-and-pinion steering gears. Technician A says if either the pinion or the rack is damaged, only the damaged part needs to be replaced. Technician B says the entire rack-and-pinion gear assembly should be replaced, even if only one of these two parts are damaged or badly worn. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____18. Technicians A and B are discussing tie-rod end removal. Technician A says that a tie-rod end puller can be used to separate the ball joint. Technician B agrees but says that using a tie-rod end fork will not ruin the seal. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____19. The illustration below shows:



From *Steering, Suspension, and Wheel Service, Unit 1*. © 1980 by State of Florida Department of State. Used with permission of Florida Department of State.

A. A rack-and-pinion steering system
B. A steering linkage with an external power piston
C. A semi-integral steering system
D. A steering linkage with a steering damper

_____20. Technician A says that after a front-end collision, a vehicle's steering column should be thoroughly inspected, even if it did not collapse during the collision. Technician B says that to avoid damaging a collapsible steering column, special care should be taken when working with components attached to it. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

ACTIVITY SHEET 1

1. D
2. D
3. B
4. A
5. B
6. B
7. D
8. B
9. D
10. A
11. A
12. B
13. C
14. D
15. A
16. C
17. B
18. A
19. D
20. C

ASSIGNMENT SHEET 1

SERVICE STEERING SYSTEMS

II

NAME ______________________________ SCORE ________

OBJECTIVE 13 **Diagnose steering column problems.**

INTRODUCTION

There are many types of problems that can be associated with the steering column. There may be problems with the different controls and switches attached to the column. Some of these problems may be mechanical in nature, such as the improper installation of an accessory control on the column. Others may be electrical, such as a defective switch. The steering wheel may be loose or may be loose in only certain tilt positions. Weak or broken springs can cause a variety of undesirable conditions. Bearings that are improperly installed or damaged can affect the steering wheel.

There are a number of problems that can occur, and there may be several possible causes for any single problem. Therefore, it is important that the specialist be able to accurately diagnose steering column problems and correct them properly.

DIRECTIONS

Read each of the following situations. Using the information given in Student Supplement 1, Steering Column Diagnostic Chart, and in other appropriate reference materials, diagnose the problems and answer the questions.

1. A customer brings his 1988 Oldsmobile Cutlass Ciera to your shop for repair. He says that he has trouble locking the steering column. You verify the complaint and find that it will not lock in any tilt position. What could cause this condition?

____

____

____

2. While test driving a vehicle, you hear noise in the steering column. Inspecting the column, you find the joints are tight and properly lubricated, the column is properly aligned, and all of the bearings appear to be in good condition. What could be the cause of the noise?

____

____

____

3. A customer complains that the steering wheel on her 1987 Chevrolet Caprice seems to be loose. You find that the support screws are loose, and you tighten them. There is sufficient clearance between the hole in the support and the pivot pin diameters, but the steering wheel is still loose. Are there other factors that could cause this looseness? If so, what are they?

____

____

____

4. The steering wheel on a 1986 Buick Regal returns poorly to the center position. What is the most likely cause of this condition, and what is the proper corrective action?

____

____

____

5. A customer calls your service center and explains that the steering column on his car will not unlock. If the shear flange on the sector shaft has not collapsed, what else could cause the column not to unlock?

____

____

____

6. While tilting the steering wheel on a late model automobile before a test drive, you hear a noise. However, no noise comes from the steering column during the test drive. What could be the cause of this noise?

____

____

____

7. One of your co-workers says the upper or lower steering shaft bearing is worn or broken on a vehicle that a customer brought to your shop. Of what condition did the customer most likely complain?

____

____

____

8. A customer brings in her vehicle that recently had steering column repairs. The vehicle has an automatic transmission, and the transmission selector is on the steering column. She complains that it takes excessive effort to shift and says that the dust seal was installed improperly. Could the improper installation of the dust seal cause this shifting problem?

____

____

____

9. A customer complains that the steering wheel on his vehicle is sometimes loose.. It is not loose in every position but is only loose in every other tilt position. What could cause the steering wheel to be loose in only these certain positions?

____

____

____

10. What problem could be caused by a broken tilt spring?

____

____

____

ASSIGNMENT SHEET 2

SERVICE STEERING SYSTEMS

II

NAME ______________________________ SCORE ________

OBJECTIVE 14

Diagnose manual steering system problems.

INTRODUCTION

One of the major systems in a vehicle is the steering system. Proper performance of the steering system is critical to the operation of the vehicle and to the safety of the passengers. For these reasons, it is important that the steering system be properly serviced and any problems corrected promptly.

Steering problems may originate in the steering linkage. Worn or damaged linkage parts or joints may be the source of the problem. In other cases, the trouble may be associated with the condition or operation of the steering gear.

The steering gear in a vehicle is in constant use. Obviously, the gear is required to turn the steering linkage, but the gear also holds the steering linkage in a required position, even if that position is with the wheels aligned straight ahead. Because of this constant use and the fact that the gear is subjected to road shock and other hazards, correct operation is essential.

The suspension and steering technician must be able to accurately diagnose and correct any problems with manual steering systems. This assignment will give you practice in this skill.

DIRECTIONS

Read each of the following situations. Using the information given in Student Supplement 2, Diagnostic Chart for Steering Systems, and in other appropriate reference materials, diagnose the problems and answer the questions.

NOTE: Some of the conditions in the following situations could be caused by problems with the suspension, by improper tire inflation, or by incorrect front-wheel alignment. For this exercise, however, diagnose the manual steering system problems that may cause the conditions described.

1. A customer has brought in a 1986 GMC pickup with manual steering. He complains that the steering wheel does not return well and is upset because he has just had the steering system serviced. If the steering column does not bind, and the wheels are correctly aligned, what are the conditions that could lead to this problem?

____

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2. A customer brings in a 1986 Ford Bronco II with manual steering. She reports that the vehicle pulls to the right as she drives it. You test drive the vehicle and find it takes about the same effort to turn the vehicle either left or right, but the vehicle does lead to the right. Is this likely to be a steering gear problem? If so, what is wrong with the steering gear?

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3. A customer reports that his 1987 Toyota Supra with manual rack-and-pinion steering rattles as the steering wheel is turned. You test drive the vehicle and find there is excessive steering wheel play. You then check the tie-rods and the steering gear mountings. All linkage and mountings seem to be tight. What is the most likely cause of this problem?

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4. You have just test driven a 1984 Dodge Rampage with manual rack-and-pinion steering. You find the steering seems loose and the vehicle wanders. What steering gear condition is likely to cause this problem? What should be done to correct it?

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5. A customer brings in his vehicle and complains that it is more difficult than normal to steer. The vehicle has a manual recirculating-ball-type steering gear. You check the worm bearing preload and find it is adjusted to specifications. If the problem is a result of a steering gear condition, what is probably wrong with the steering gear? How should the problem be corrected?

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6. A customer has brought in a larger, older model vehicle with manual steering and complains that there seems to be too much play in the steering wheel. You check the gear and find it is adjusted properly. The tie-rod ends also seem to be properly adjusted. What could be the problem? What corrective action is necessary?

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7. After replacing a vehicle's steering gear, you test drive the vehicle. The steering wheel does not return well. Since you have just replaced the gear, you know that improper lubrication or improper adjustment cannot be the cause. The steering column does not bind, either. What could be the problem?

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8. While test driving an older model, American-made car with a recirculating-ball type steering gear, you notice there is too much steering wheel play. After completing the test drive, you raise the vehicle, check the linkage, and find all parts and joints appear to be in good condition. The steering gear is securely mounted. What is the most likely cause of this excessive steering wheel play, and what corrective action is necessary?

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9. The owner of a late model vehicle with rack-and-pinion steering brings in her vehicle to your shop. She says she feels a roughness when she turns the steering wheel. What could cause this condition?

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10. A customer brings in his vehicle and says the steering wheel is slow to return. His vehicle is equipped with a manual rack-and-pinion steering gear. Could a sticking control valve be the cause of this steering problem?

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ASSIGNMENT SHEET 3

SERVICE STEERING SYSTEMS

II

NAME ______________________________ SCORE ________

OBJECTIVE 15 **Diagnose power steering system problems.**

INTRODUCTION

The vehicle's steering system, whether manual or power-assisted, must perform correctly to ensure safe and proper operation of the vehicle. Power steering systems, like manual steering systems, may have problems that originate in the steering linkage or in the steering gear. However, unlike manual systems, there also may be problems with the power steering pump or with parts such as hoses and belts connected to the pump.

A power steering system is much more complicated than a manual system. Therefore, diagnosing problems in power-assisted systems is a more complicated task. The task is made even more difficult by the fact that so many different designs of power steering systems are used. The service technician must correctly determine the type of system in use, locate the correct references for that particular system, and then accurately diagnose the problem. This assignment sheet will give you practice diagnosing power steering system problems.

DIRECTIONS

Read each of the following situations. Using the information given in Student Supplement 2, Diagnostic Chart for Steering Systems, and in other appropriate reference materials, diagnose the problems and answer the questions.

NOTE: Some of the conditions in the following situations could be caused by problems with the suspension, by improper tire inflation, or by incorrect front-wheel alignment. For this exercise, however, diagnose the *power steering system* problems that may cause the conditions described.

1. A customer has brought in a 1984 Ford Thunderbird. He states that the car makes a whining noise when he turns the steering wheel, especially if he turns the wheels to near their stops. What two things should you first suspect and check?

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2. You are servicing a vehicle with a Saginaw power steering gear and nonintegral power cylinder. The driver has complained that sometimes the steering seems loose, while at other times it is stiff. The fluid level and belt tension are correct, but some of the steering linkage seems to be worn. Can worn parts cause this problem?

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3. An older model vehicle has been brought into your shop. The owner says there must be a leak in the power steering system because lately there has been power steering fluid on the driveway where the car is usually parked. You are also told that a new pump and new hoses were recently installed. Upon inspection you find that the hose connections are secure, and the power steering fluid level is above the recommended level. What is the most likely cause of the leakage?

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4. A customer brings his vehicle with power steering to your shop for repair. He says that recently the vehicle has become extremely difficult to steer. He also says that the steering gear was recently adjusted and the mounting tightened. You check the drive belt tension, and it appears to be correct. What conditions could cause this problem?

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5. When you test drive a vehicle, you find the steering wheel play seems to be excessive. Is this condition likely to be caused by a problem in the power steering pump? If so, what should be done to repair the pump?

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6. A customer brings in a vehicle which has a power recirculating-ball type steering gear. The customer complains that the steering wheel is slow to return even though the linkage was just lubricated. What could cause this problem?

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7. A vehicle has been brought into your shop. The owner said the front wheels were aligned a few days ago, and ever since, the vehicle seems to wander. If the steering linkage and gear mountings were checked during the alignment service, what would be the most likely cause of this condition?

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8. After adjusting a vehicle's manual steering gear, you test drive the vehicle. The steering wheel does not return well, but the steering column does not bind. The gear appeared to be properly lubricated when you adjusted it. What could cause the steering wheel on this vehicle not to return well?

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9. A customer brings in a vehicle with a recirculating-ball type steering gear. She complains of steering wheel roughness. What could be the cause of this condition, and how should it be corrected?

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10. The owner of an older model vehicle with power steering brings his vehicle to your shop. He says power steering fluid is leaking, and the pump groans loudly when the wheels are turned. There seems to be no problem with the belt, hoses and hose connections, and the fluid level is correct. What could be the cause of these problems?

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ASSIGNMENT SHEET 1

1. Shoe seized on its pivot pin; shoe grooves may have burrs or dirt; shoe lock spring weak or broken
2. Loose sight shields; shaft lock snap ring not seated
3. Defective or missing anti-lash spring in spheres; upper bearing not seated in housing; upper bearing inner race seal missing; bearing preload spring missing or broken
4. Steering column U-joints misaligned—realign steering column U-joints
5. Damaged lock bolt, lock cylinder, housing, sector, rack, or park lock cable
6. Upper tilt bumpers worn; tilt spring rubbing in housing
7. Noise in steering column
8. Yes
9. Loose fit between shoe and shoe pivot pin; shoe not free in slot
10. Steering wheel failing to return to the top tilt position

ASSIGNMENT SHEET 2

1. Tight steering linkage; incorrect or insufficient lubricant in gearbox; defective steering gear
2. No
3. Improperly adjusted gear
4. Loose steering gear mounting—tighten mounting bolts to specifications; improper gear adjustment—adjust to specifications
5. Improperly adjusted gear (sector shaft adjustment too tight)—adjust to specifications; insufficient or incorrect lubricant—flush, if necessary, and refill with recommended lubricant

6. Worn ball joints in steering linkage—replace components containing worn ball joints; loose steering gear mounting—tighten to specifications

7. Lack of lubricant in steering linkages; tight steering linkage

8. Gear improperly adjusted—adjust gear to specifications

9. Worn pinion shaft bearings or bearing races

10. No

ASSIGNMENT SHEET 3

1. Low fluid level and loose drive belt or pulley

2. Yes

3. Too much fluid in reservoir

4. Low fluid level; pump binding due to incorrect fluid or improper fluid level; improper adjustments

5. No

6. Sticking control valve or defective steering gear; incorrect or insufficient lubricant in gearbox; improperly adjusted steering gear

7. Improper gear adjustment; steering wheel not centered on shaft

8. Lack of lubricant in steering linkages; sticking control valve

9. Worn wormshaft bearings or bearing races—replace bearing assemblies

10. Leaking pump, defective seals; defective pump

JOB SHEET 1

SERVICE STEERING SYSTEMS

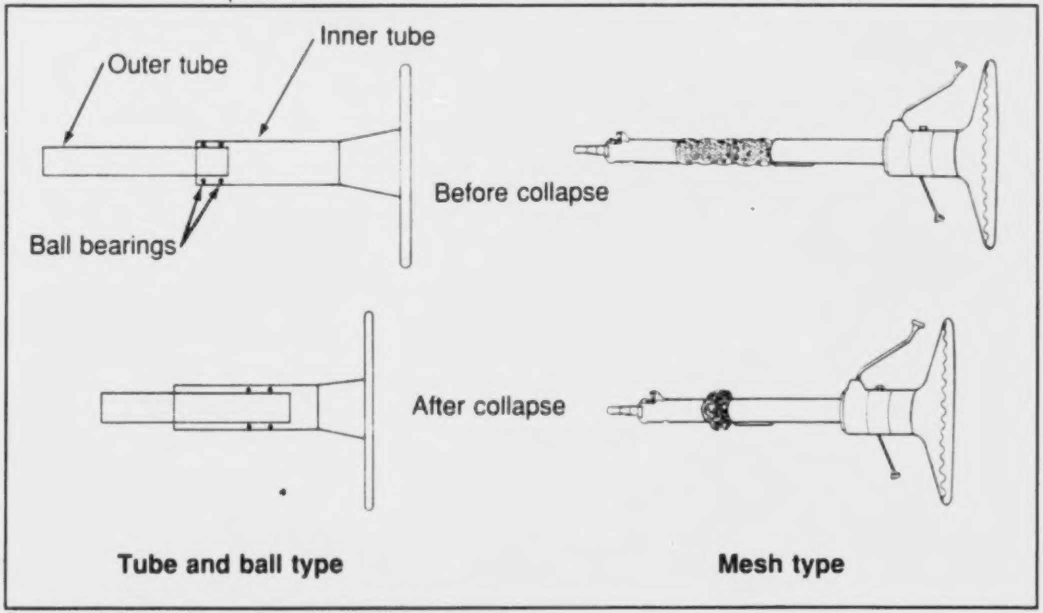
II

OBJECTIVE 16A **Inspect and replace steering column components.**

INTRODUCTION

Driver safety concerns have brought about many changes in steering wheel design. Early steering columns were nothing more than a pole with a wheel mounted on one end. Today's steering columns contain mechanisms that give way and allow the steering column to collapse. Because the force of the collision is absorbed by the steering column, this feature is called an *energy-absorbing* design. Two of the most popular designs for collapsible steering columns are shown in Figure 1.

FIGURE 1



Tube and ball type **Mesh type**

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Other design features add to the procedures required to service steering columns. Many steering wheels can be adjusted for driver comfort. For example, some steering columns allow the driver to move the steering wheel closer or farther away. This is called a *telescoping* steering column. A *tilting* steering wheel pivots up and down at the end of the steering column to suit driver preference. Other steering wheels pivot horizontally toward the center of the vehicle to make it easier for the driver to get in or out.

Steering columns also provide routing for control linkages and wiring for devices such as cruise control, turn signal indicators, windshield washer and wipers, hazard signals, transmission gear shifter, and other features. Additionally, most vehicles have the ignition switch and locking mechanism on the steering column. Because of the differences in steering column designs, the only sure way to perform the correct service procedures is to refer to the service manual for the make and model with the features on that vehicle.

The most common service procedures on the steering column involve the repair of the many devices associated with the steering column. However, a vehicle's steering column should be inspected any time the vehicle has damage resulting from a front-end or rear-end collision. Service to the steering column itself is generally limited to the inspection and replacement of bearings, U-joints, linkages, and rubber and plastic parts.

Guidelines:

- Be careful when working on energy-absorbing steering columns, because rough handling or excessive pressure can cause the column to collapse. Never pound on the end of the steering shaft with a hammer.

- Use caution when working on vehicles equipped with supplemental restraints such as air bags. Follow the manufacturer's instructions.

- Any time the steering column is disassembled, inspect all the exposed parts and lubricate the moving parts according to the manufacturer's instructions.

- Replace any defective steering column parts. Do not attempt to repair them.

- Use any special tools recommended by the vehicle manufacturer and be sure that you know how to use them correctly.

- Follow the vehicle manufacturer's directions regarding fasteners and torque specifications. Do not use substitute fasteners that do not meet manufacturer's specifications.

EQUIPMENT AND EQUIPMENT

- Vehicle
- Appropriate service manual
- Other equipment and materials as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

JOB SHEET 2

SERVICE STEERING SYSTEMS

II

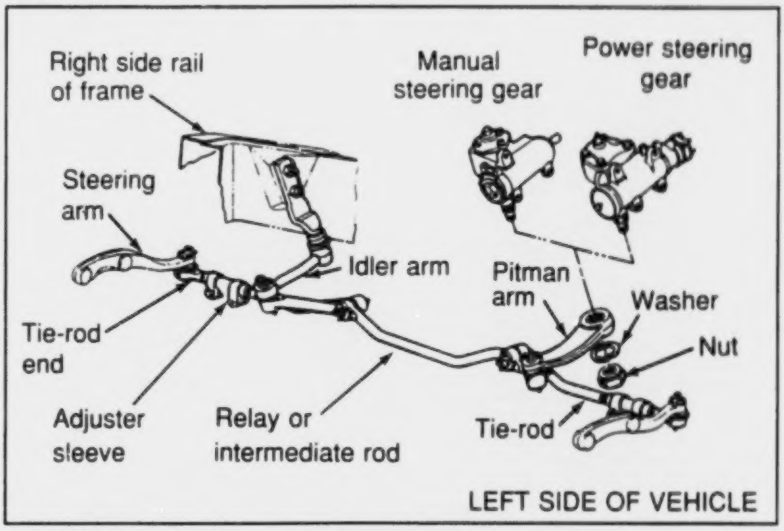
OBJECTIVE 16B

Inspect and replace a pitman arm.

INTRODUCTION

The pitman arm moves constantly while the vehicle is in motion. Obviously, the pitman arm is in use and subject to wear when the wheels are being turned. Not as apparent is the fact that since the pitman arm is always holding the wheels in position, it absorbs much of the vibration from road shock transmitted through the wheels and the steering linkage. The pitman arm is also subject to damage from road hazards such as potholes, rocks, and ruts.

FIGURE 1


Right side rail of frame
Manual steering gear
Power steering gear
Steering arm
Idler arm
Pitman arm
Washer
Nut
Tie-rod end
Adjuster sleeve
Relay or intermediate rod
Tie-rod
LEFT SIDE OF VEHICLE

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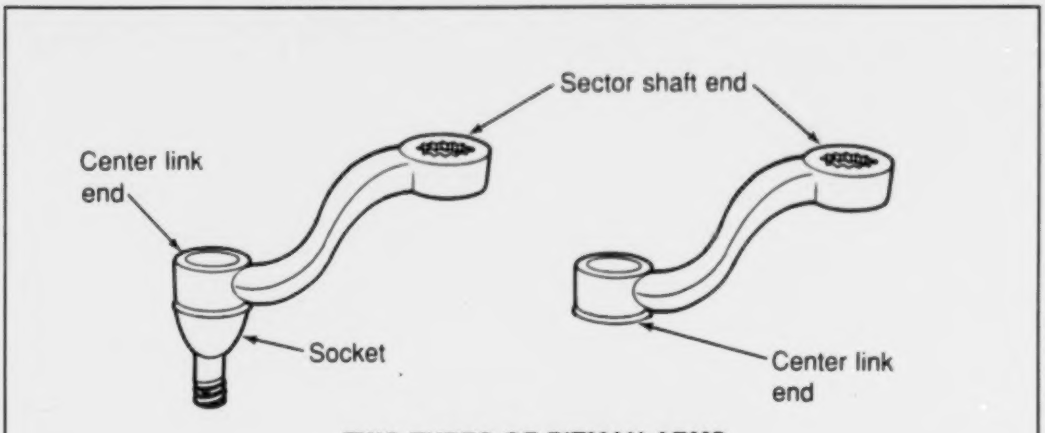
There are two types of pitman arms. The primary difference between the two types is in how they are connected to the steering linkage. Some pitman arms include the socket of the ball and socket joint that connects it to the center link. Others do not; the socket portion of the connection is attached to the center link. (Figure 2)

FIGURE 2



TWO TYPES OF PITMAN ARMS

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The most likely areas for wear in the pitman arm are the point where the arm bolts to the gearbox sector shaft and the connection with the center link. The arm should be checked visually and shaken to see if there is slack in the connections.

EQUIPMENT AND MATERIALS

- Vehicle with a parallelogram steering linkage
- Appropriate service manual
- Wheel Alignment Check Sheet
- Eye protection
- Jacks and jack stands or ramps
- Basic hand tool set
- Shop cloths
- Torque wrench
- Pitman arm puller specified by manufacturer
- Appropriate replacement parts
- Dial indicator

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

PROCEDURE

Inspect and remove pitman arm

NOTE: Be sure to note all inspection findings on the Wheel Alignment Check Sheet.

1. Visually check the linkage to see if the center link is parallel to the ground; if it is **not** parallel to the ground, either the pitman arm, idler arm, or center link is loose, damaged, or bent.

   NOTE: When inspecting the pitman arm and steering linkage, note which component, the center link or the pitman arm, includes the socket. This is important in determining whether the pitman arm or the center link needs to be replaced.

2. Raise the front of vehicle and support properly.

   NOTE: If ramps or jacks and jack stands are not used, a hydraulic lift may be used to raise the entire vehicle. If jack stands or a lift is used, try to keep the steering linkage at an angle similar to what the alignment would be if the vehicle were on the ground.

3. Use a shop cloth to wipe the grease from the pitman arm and connections.

4. Check nuts for looseness and to see that cotter pins, if used, are in place; if the nuts are loose, tighten them to specifications.

5. Check the ball and socket connection by grasping the pitman arm firmly and pushing up and pulling down.

6. If there is movement, measure the movement using a dial indicator and compare the measurement with the manufacturer's specifications.

   NOTE: If the pitman arm contains the socket portion of the connection and if movement exceeds specifications, the pitman arm must be replaced.

7. Remove the pitman arm using the recommended tools.

   CAUTION

   Do not hammer or use other force to separate steering system components.

8. If the center link was **not** parallel to ground during inspection (Step 1), check to see if the pitman arm is bent by comparing it with one known to be good.

9. If the pitman arm is bent, replace it.

PROCEDURE

Replace a pitman arm

1. Check to be sure the wheels are in a straight ahead position.

    a. Turn the steering wheel fully to one stop.

    b. Turn the steering wheel fully to the other stop, counting the turns.

    c. Turn the steering wheel back exactly halfway between the stops.

2. Align the pitman arm with the center link connection.

3. Install the pitman arm on the sector shaft, being careful to align the sector shaft splines and the pitman arm correctly.

    NOTE: In some designs a large notch or other feature is used to ensure correct engagement.

4. Install washers and retaining nuts and torque to specifications.

5. Install cotter pins if necessary.

    NOTE: A cotter pin may or may not be used with this installation, depending on the type of nut used. However, if a cotter pin is to be used, always install a *new* cotter pin. Some vehicles are equipped with self-locking nuts. Manufacturers may recommend replacing these any time they are removed.

6. Install the ball stud in the socket.

7. Install the retaining nut and torque to specifications.

8. Install a cotter pin if necessary.

9. Lubricate as recommended by the vehicle manufacturer.

10. Check the installation for looseness

    NOTE: If the pitman arm was properly installed and looseness persists, another problem is present.

11. Have another person turn the wheels fully left and fully right; observe for proper movement.

    NOTE: If the vehicle is equipped with power steering, this step must be done with the engine running and exhaust removal equipment installed.

12. Lower the vehicle to the floor.

13. Reinspect the center link to make sure it is parallel to ground.

    NOTE: If the installation is loose, if wheels move improperly, or if the center link is **not** parallel to ground, then another problem is present. Vehicle toe will need to be checked.

14. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 3

SERVICE STEERING SYSTEMS

II

OBJECTIVE 16C

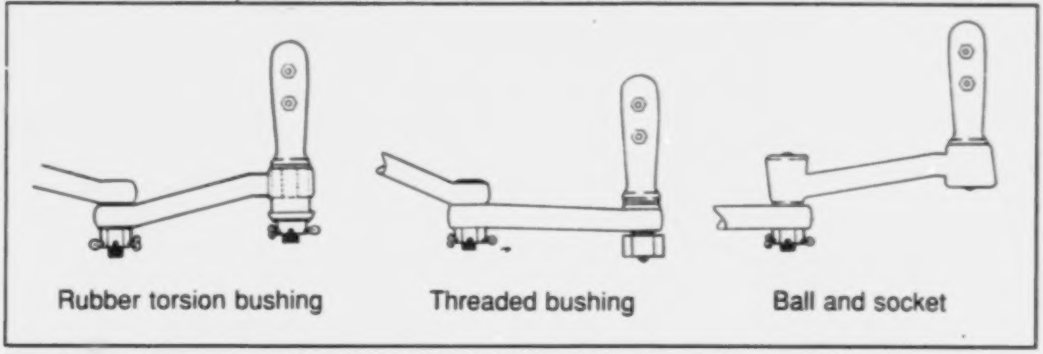
Inspect, replace or repair, and install an idler arm and mounting.

INTRODUCTION

The idler arm is often overlooked in steering linkage service, even though it receives much more wear than the pitman arm. The idler arm is mounted to the frame, and these mountings can wear or work loose. As a result, the idler arm and mountings are important parts to check when inspecting the steering linkage.

There are several types of connections used to join idler arms to their supports; some are shown in Figure 1. Since there are other types besides these, it is important to follow service manual instructions when inspecting or servicing idler arms.

FIGURE 1



Rubber torsion bushing

Threaded bushing

Ball and socket

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One type of connection is a threaded steel bushing used to join the idler arm and the support. This bushing uses right-hand threads on the outside and left-hand threads on the inside. Rubber torsion bushings are also used to connect idler arms to their supports. The third type uses a ball and socket at the center link joint. While the bushings can be replaced if worn, the ball and socket design cannot be repaired, and the entire idler arm and mounting must be replaced as an assembly if damaged.

EQUIPMENT AND EQUIPMENT

- Vehicle
- Appropriate service manual
- Wheel Alignment Check Sheet
- Eye protection
- Jack and jack stands or ramps

- Appropriate replacement parts
- Shop cloths
- Lubricant
- Basic hand tool set
- Vise (for threaded bushing design)
- Hydraulic press and bushing tool (for rubber torsion bushing design)
- Tie-rod puller or fork (for ball and socket design)
- Approved cleaning solvent
- Wooden blocks
- Dial indicator
- Other equipment and materials as required by procedure

CAUTION
Always check the procedure in the vehicle's service manual before beginning any service or repair.

PROCEDURE

Inspect the idler arm and support

NOTE: Be sure to note all inspection findings on the Wheel Alignment Check Sheet.

1. Visually check the linkage to see if the center link is parallel to the ground; if it is **not** parallel to ground, then either the pitman arm, idler arm, or center link is loose, damaged, or bent.

2. Raise the front of the vehicle and support it properly.

   NOTE: If ramps or jacks and jack stands are not used, a hydraulic lift may be used to raise the entire vehicle. If jack stands or a lift is used, try to keep the steering linkage at an angle similar to what the alignment would be if the vehicle were on the ground.

3. Use a shop cloth to wipe the grease and dirt from the idler arm, support, and connections.

4. Check nuts for looseness and to see that cotter pins are in place; if loose, torque to specifications.

5. Check support mounting bolts for looseness; if loose, torque to specifications.

6. Shake the rear of the right front tire in and out while observing the idler arm for looseness.

7. Check the idler arm for looseness by grasping the idler arm firmly and pushing up and pulling down on it.

8. If there is movement, measure the movement with a dial indicator and compare the measurements with manufacturer's specifications.

   NOTE: If movement exceeds manufacturer's specifications, the idler arm must be serviced.

9. Visually check the idler arm and mounting for damage and wear.

10. If the idler arm is **not** loose and does **not** show damage or excessive wear, reinstall the fasteners and torque to specifications.

11. If the idler arm is loose or worn, replace or repair it following the procedure correct for type of idler arm being serviced.

PROCEDURE **Replace or repair and install an idler arm and mounting**

PROCEDURE **NOTE:** Refer to the appropriate service manual for make and model as equipped.

JOB SHEET 4

SERVICE STEERING SYSTEMS

II

OBJECTIVE 16D

Inspect and replace a center link.

INTRODUCTION

The center link, or relay rod as it is called in some designs, is connected to the pitman arm, the idler arm, and the two tie rods. Since it is joined to so many different parts, the center link is subject to wear in several places. It is important that the steering technician carefully inspect the center link and replace it if necessary whenever the steering system is serviced.

Guidelines:

- Replace worn or bent parts rather than repairing them. Steering linkage parts cannot be reshaped by heating or bending. Nor should they be repaired by welding.
- Be sure that studs, holes, and nuts are free from dirt and grease before connecting the center link.
- Refer to the manufacturer's parts guide to select the correct replacement center link. The new part should meet vehicle manufacturer's specifications.

EQUIPMENT AND EQUIPMENT

- Vehicle
- Appropriate service manual
- Other equipment and materials as required by procedure

PROCEDURE

NOTE: Refer to appropriate service manual for make and model as equipped.

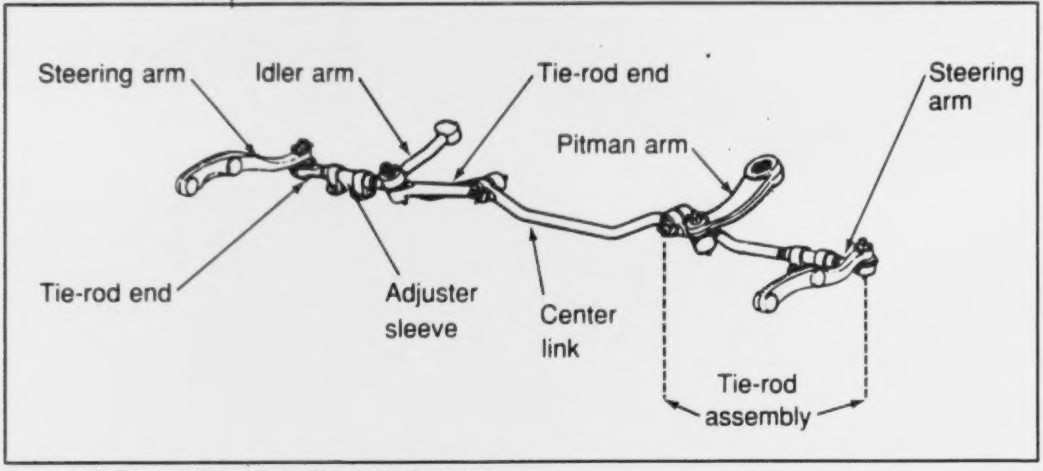
OBJECTIVE 16E **Inspect and replace a tie-rod assembly.**

INTRODUCTION

The tie-rod is a very important link in the steering system. Not only does the tie-rod connect the center link to the steering arm, but it also allows vehicle toe to be adjusted. The length of the tie-rod assembly can be adjusted, changing the toe setting. There are many designs used to permit tie-rod length adjustment in both parallelogram and rack-and-pinion steering designs, but with any design it is important to thoroughly inspect the threaded parts that permit adjustment.

One of the most common methods of adjusting tie-rod length uses a threaded adjusted sleeve to join the two tie-rod ends. The sleeve is threaded in such a way that turning the sleeve one way lengthens the tie-rod assembly, while turning the sleeve the other way shortens the assembly. Clamps are used to hold the sleeve in place during normal vehicle driving. The type of tie-rod assembly that is found on a parallelogram steering linkage is shown in Figure 1.

FIGURE 1



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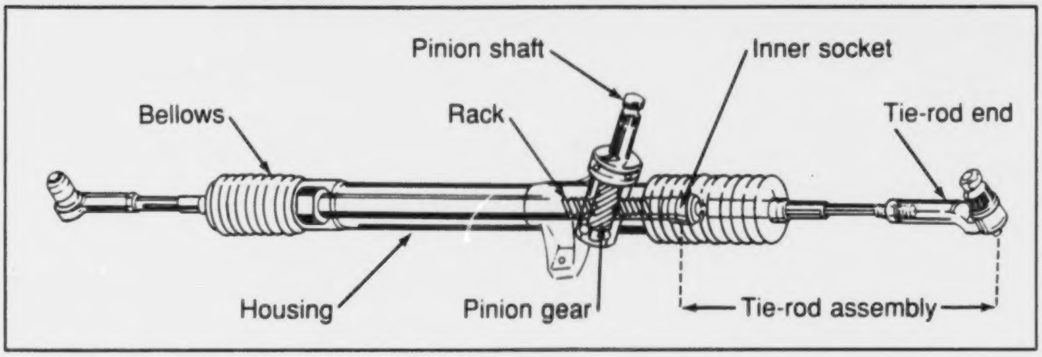
The tie-rod assemblies found on rack-and-pinion steering linkages contain fewer parts and are threaded to allow for adjustment. Figure 2 shows the tie-rods on a rack-and-pinion design.

FIGURE 2

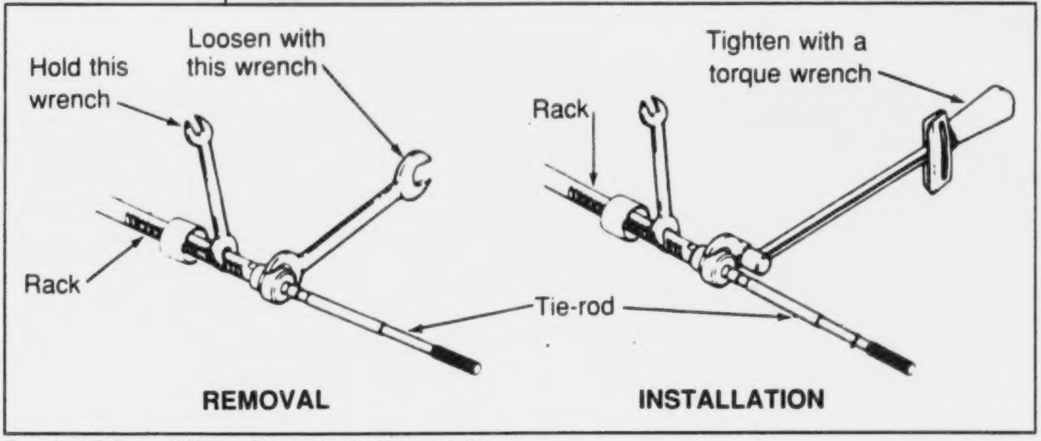

Pinion shaft
Inner socket
Bellows
Rack
Tie-rod end
Housing
Pinion gear
Tie-rod assembly

Used with permission of Chrysler Corp.

The tie-rod end may be joined to the steering arm in several different ways, and the point where the tie-rod and the steering linkage join requires careful attention. Many designs use a ball socket held in place by springs, cotter pins, or other devices. Some designs use threaded studs that go through the steering knuckle from underneath or go over the top and down through the steering arm.

When unfastening the tie-rod from the rack or tightening the ball socket on a rack-and-pinion steering linkage, the rack teeth can be easily damaged. Be sure to use the correct size wrench. (Figure 3)

FIGURE 3


Hold this wrench
Loosen with this wrench
Rack
Tie-rod
REMOVAL
Tighten with a torque wrench
Rack
INSTALLATION

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EQUIPMENT AND MATERIALS

- Vehicle with a parallelogram steering linkage
- Vehicle with a rack-and-pinion steering linkage
- Appropriate service manuals

- Eye protection
- Lift or jack and jack stands
- Basic hand-tool set
- Tie-rod end fork or puller specified by vehicle manufacturer
- Torque wrench
- Penetrating oil
- Wire brush
- Shop cloths
- Appropriate replacement parts
- Tape measure or measuring stick
- Chasis lubricant

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

PROCEDURE

Inspect tie-rod ends

1. Raise the vehicle and support it safely.

2. Use a shop cloth to wipe any grease or dirt from the tie-rod assembly.

3. Visually inspect the tie-rod ends for damage and wear and check the seals for damage.

   NOTE: If tie-rod ends are damaged, worn, or bent, they must be replaced. If seals are damaged, refer to the vehicle manufacturer's service manual to see if replacement seals are available. If not, replace the entire tie-rod assembly.

4. Check the tie-rod ends for looseness by firmly grasping each tie-rod end and pushing up and pulling down.

5. If any up-and-down movement is present, replace the tie-rods.

6. If up-and-down movement is not present and the tie-rod ends seem to be loose, adjust to remove the looseness.

7. If the tie-rods cannot be adjusted, and they are worn, bent, or damaged, replace them.

PROCEDURE

Remove and replace a tie-rod assembly on a parallelogram linkage assembly

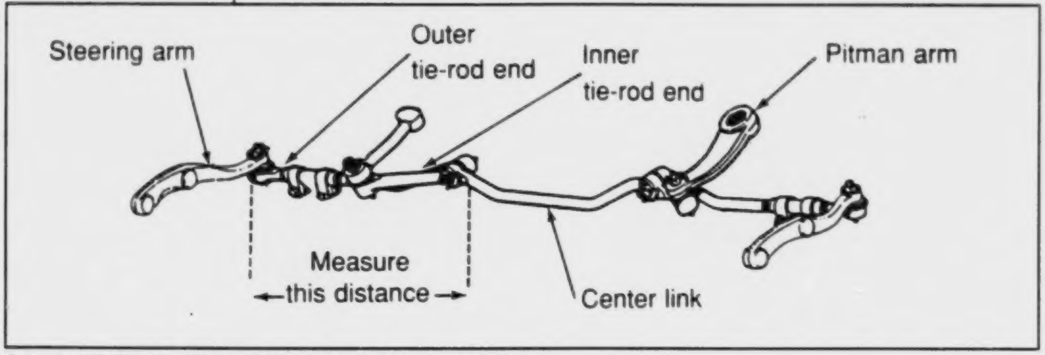
NOTE: The procedures for removing the outer tie-rod end and for removing the inner tie-rod end are basically the same. The inner tie-rod end connects to the center link, and the outer tie-rod end connects to the steering arm. They both connect to the adjuster sleeve. Replace one tie-rod at a time.

1. Clean the tie-rod threads with a wire brush.

2. Measure the tie-rod assembly from the stud going through the center link to the stud going through the steering arm; record the measurement. (Figure 4)

   NOTE: This measurement will be needed when installing the new tie-rod ends so that an approximate toe setting can be made.

FIGURE 4



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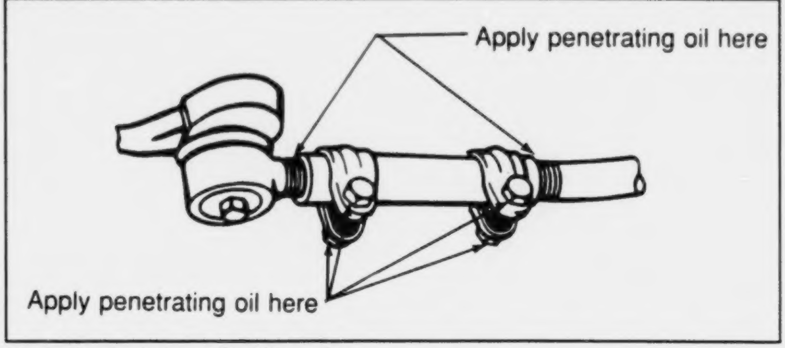
3. Apply penetrating oil to the tie-rod end threads and to the adjuster sleeve clamp bolts. (Figure 5)

FIGURE 5



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4. Loosen the adjuster sleeve clamp bolts.

5. Remove the cotter pin from the nut on the tie-rod end and discard it.

6. Remove the nut.

7. Disconnect the joint between ball stud and socket using a tie-rod end fork or the puller recommended by the vehicle manufacturer.

   NOTE: Never use a tie-rod end fork to remove a tie-rod end that is **not** going to be replaced. Using a fork to remove it will damage the ball joint seal.

8. Unscrew the tie-rod end from the adjuster sleeve.

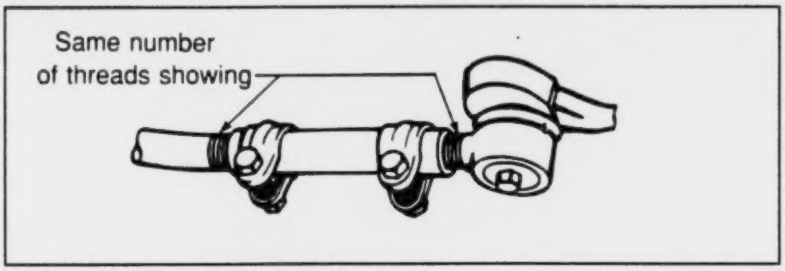
9. Inspect the adjuster sleeve; if the threads are damaged, replace the adjuster sleeve.

10. Obtain the proper replacement tie-rod end.

    NOTE: Be sure the new tie-rod end is correctly threaded for the installation. Tie-rod ends may look identical except for the directions of their threads.

11. Screw the new tie-rod end into the adjuster sleeve until the same number of threads shows on both the outer and the inner tie-rod ends. (Figure 6)

FIGURE 6



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12. Place the ball stud in the socket.

13. Measure the tie-rod assembly from the stud going through center link to the stud going through the steering arm.

14. If the measurement does not match the measurement in Step 2, remove the ball stud from the socket and adjust the tie-rod ends into or out of the adjuster sleeve until the measurement is equal to that recorded in Step 2.

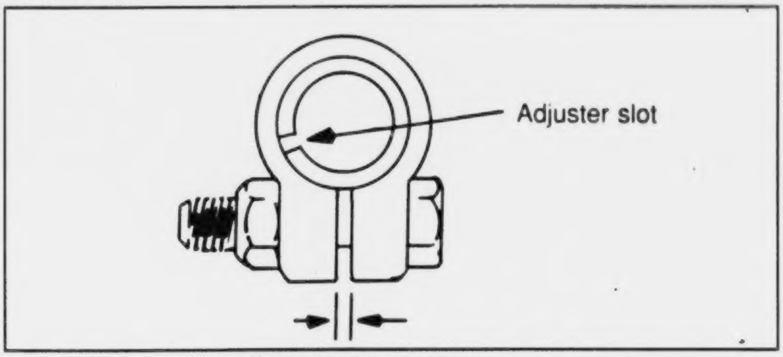
15. Install a nut on the ball stud and torque to specifications.

16. Install a new cotter pin.

17. Check the position of the adjuster sleeve clamps to be sure that they are positioned according to manufacturer's instructions. (Figure 7)

    NOTE: The slot in each clamp should not align with the slot in the adjuster sleeve.

FIGURE 7



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18. Tighten the adjuster sleeve clamp bolts.

CAUTION

Do not overtighten the bolts. Overtightening can damage the adjuster sleeve threads and make it difficult to unscrew the tie-rod ends from the adjuster sleeve.

19. Align the front end before considering the vehicle road-worthy.

20. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

PROCEDURE

Remove and replace the tie-rod assembly on a rack -and-pinion linkage.

NOTE: Refer to the appropriate service manual for make and model as equipped.

OBJECTIVE 16F

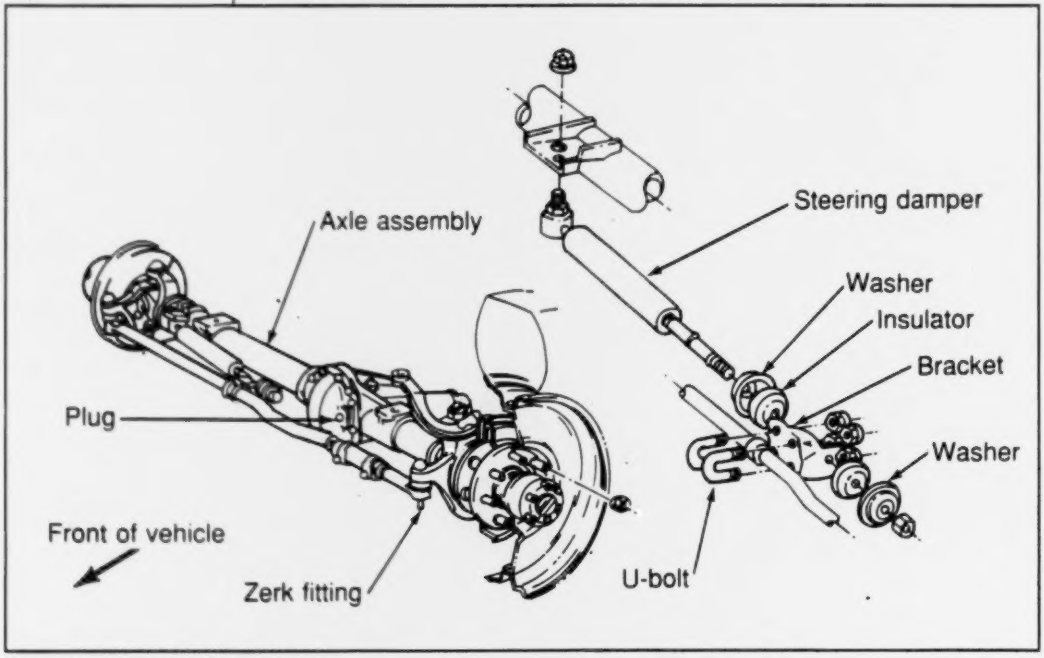
Inspect and replace a steering damper.

INTRODUCTION

The steering damper, also called a steering stabilizer or hydraulic stabilizer, is often used on four-wheel drive vehicles and on larger trucks. Some import cars have a steering damper, although it is usually an option on the smaller import cars.

The steering damper acts like a shock absorber, using hydraulic pressure to cushion road shock and shimmy. If the damper is defective or loose, it can cause steering problems, including loose steering, clunking noises, or increase in the road shock and shimmy it was designed to cushion. Figure 1 shows a damper installed between the center link and the frame.

FIGURE 1


Steering damper
Axle assembly
Washer
Insulator
Bracket
Plug
Washer
Front of vehicle
Zerk fitting
U-bolt

Used with permission of Ford Motor Co.

The most common failure of steering dampers is hydraulic fluid leakage. Some leakage is normal, but excessive amounts indicate a bad seal. The damper is also subject to damage from road debris and other obstacles. In either case, the damper cannot be repaired and must be replaced.

Guidelines:

- Be sure to check the condition of the connections to the steering linkage and/or frame.

- Position the wheels in the straight ahead position when removing or installing a steering damper to be sure that the damper is not extended.

- Use the correct tools for damper removal and installation.

- Choose the correct replacement steering damper. If you are installing a damper on a vehicle not already equipped with one, make sure the damper is specifically designed for that vehicle.

- After installation, turn the wheels from one stop to the other to be sure that the damper operates correctly. If the damper is improperly aligned, steering may be restricted.

EQUIPMENT AND MATERIALS

- Vehicle with steering damper
- Appropriate service manual
- Other equipment and materials as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

JOB SHEET 7

SERVICE STEERING SYSTEMS

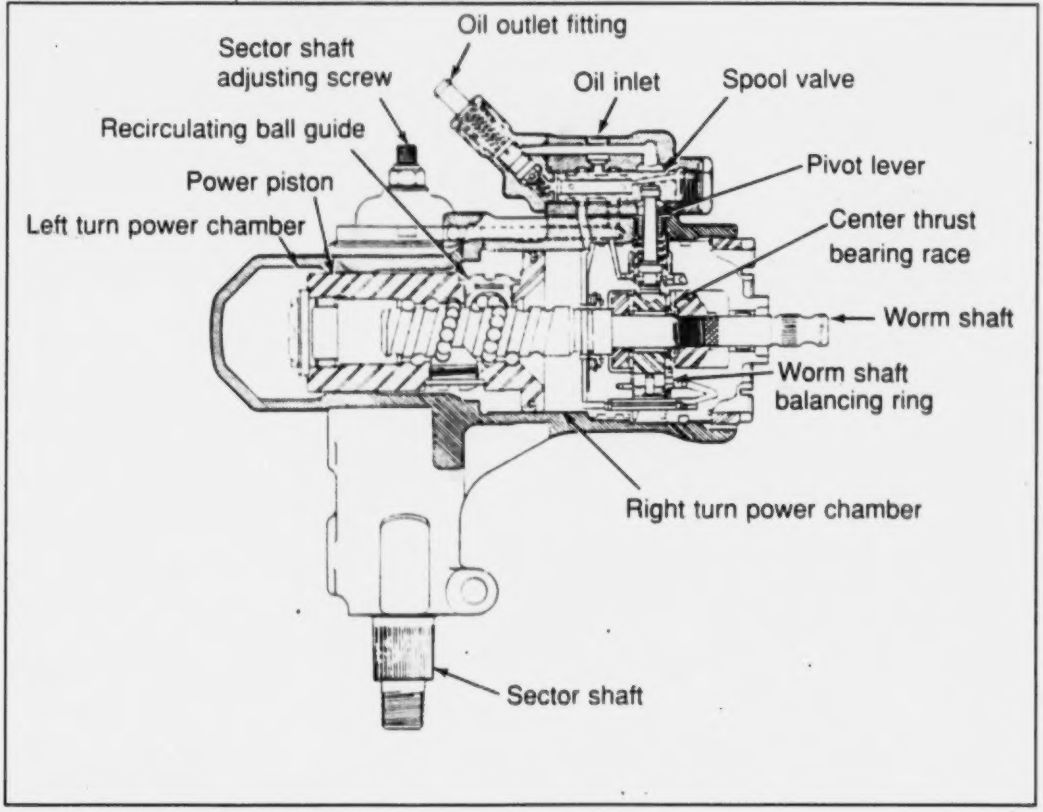
OBJECTIVE 16G

Adjust, or replace and adjust, a power recirculating-ball type steering gear.

INTRODUCTION

Adjustments made to a *manual* recirculating-ball type steering gear are also made to a *power* recirculating-ball type steering gear. The procedure for making the sector shaft adjustment is similar to the manual gear adjustment. The worm bearing preload is also adjusted on power steering gears. However, the procedure for the actual adjustment is different, as are the methods of gaining access to the adjusting mechanisms. A power recirculating-ball type steering gear is shown in Figure 1.

FIGURE 1


Oil outlet fitting
Sector shaft adjusting screw
Oil inlet
Spool valve
Recirculating ball guide
Pivot lever
Power piston
Center thrust bearing race
Left turn power chamber
Worm shaft
Worm shaft balancing ring
Right turn power chamber
Sector shaft

Used with permission of Chrysler Corp.

When making a diagnosis, the service technician must consider the most likely cause of the problem. Often problems can be corrected by simply adjusting the steering gear. Sometimes, however, the problems may persist after adjustment. In this case, the service technician should test the power steering pump. If the pump operates correctly and the problems persist after adjustment, it is likely that the steering gear needs to be replaced.

As with many of today's automotive service jobs, it is often more cost-effective to replace the steering gear rather than recondition it. In many instances, reconditioning is not even possible because replacement parts are not available. The service technician may install a new, rebuilt, or salvaged part. Whichever part is installed, it must be adjusted after installation. The service technician should always refer to the vehicle manufacturer's service manual when adjusting or replacing a power recirculating-ball type steering gear.

EQUIPMENT AND MATERIALS

- Vehicle with a power recirculating-ball type steering gear
- Appropriate service manual
- Other equipment and materials as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

SERVICE STEERING SYSTEMS

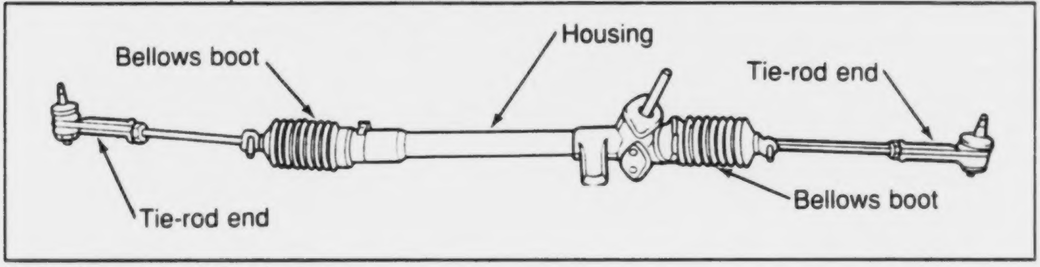
OBJECTIVE 16H

Inspect and replace a bellows boots.

INTRODUCTION

Bellows boots are often used to protect parts of rack-and-pinion steering systems. They are made of silicone and/or neoprene and are shaped with accordion pleats. The boots fit over the ends of the rack housing and allow movement while protecting the parts from dirt and moisture. (Figure 1)

FIGURE 1



Used with permission of Chrysler Corp.

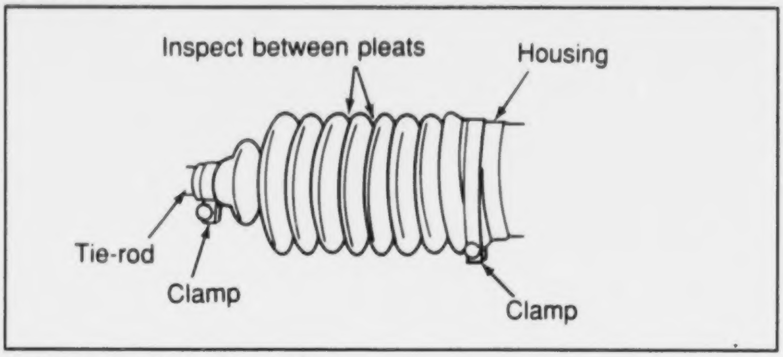
Because the boots are exposed to weather and road hazards, it is not unusual for the boots to crack, split, or separate from their fittings. When this happens, replacement should be immediate. Dirt or water may seriously damage the parts inside.

The boots are relatively inexpensive, and replacement is fairly simple. However, replacement of the rack, pinion, and other components due to a failed bellows boot is expensive and involved. The boots should be inspected regularly, including any time service is done under the vehicle. If defects are found, the defective boot should be replaced.

Guidelines:

- Grasp the pleats and spread them apart to check the crevices for splits or cracks. (Figure 2)

FIGURE 2



Used with permission of Chrysler Corp.

- Make sure replacement boots meet manufacturer's specifications.

- Replace the clamps if necessary and tighten the clamps just enough to ensure the boot fits snugly.

- Count the number of exposed threads on the tie-rod before disconnecting it. After installing the new boot, reconnect the tie-rod, leaving this number of threads exposed. This should be done to maintain the proper toe setting.

EQUIPMENT AND MATERIALS

- Vehicle
- Appropriate service manual
- Other equipment and materials as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

JOB SHEET 9

SERVICE STEERING SYSTEMS

II

OBJECTIVE 16I

Replace a manual rack-and-pinion steering gear.

INTRODUCTION

A rack-and-pinion steering system has fewer moving parts than systems having a parallelogram design. Although there are fewer parts to wear out and fewer to service, road shock and vibration are felt more directly by the driver.

An indication of a need for service in a rack-and-pinion system is noise or roughness in the steering gear. This might be heard as a loud knock, especially as the steering wheel is turned from stop to stop. A faint knock may be heard at other times, even in a properly adjusted steering gear, especially on rough roads or during extremely sharp turns. However, if the noise seems unusual or occurs under less extreme conditions, then the steering gear should be replaced.

Guidelines:

- Always replace the complete rack-and-pinion assembly as a unit. The replacement assembly may be new or a rebuilt one.
- Check the lubricant and adjust it to the proper level before replacing the gear. After replacement, check the lubricant level again.
- Before replacing the assembly, check the rack bushings and mountings. Excessive steering wheel play, which is usually an indication of a worn or damaged gear, may be caused by worn or loose bushings or mountings. It may be possible that only the mountings need to be tightened or the bushings replaced.
- Be sure that the steering wheel remains in the straight ahead position while replacing the gear assembly.
- Be sure to align the front end after replacement. The vehicle cannot be considered road ready until front-end alignment has been done.

EQUIPMENT AND MATERIALS

- Vehicle with manual rack-and-pinion steering gear
- Appropriate service manual
- Other equipment and materials as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

JOB SHEET 10

SERVICE STEERING SYSTEMS

II

OBJECTIVE 16J

Perform a power steering pressure test.

INTRODUCTION

Power steering pump problems often cause unusual noises and variations in the amount of steering assist. As with any diagnostic procedure, the service technician should check the simplest and most likely causes first. For example, fluctuations in the amount of power assist and some noises may result from incorrect belt adjustment or from a defective belt. These may also be caused by low fluid levels or improper fluids.

Specific noises may be caused by several different types of problems. Some technicians listen to the pump with a stethoscope to detect grinding noises or other mechanical sounds. Groaning at low speeds during light acceleration may result from air in the system. This condition can be corrected only by bleeding the system. A low hissing sound should not cause concern, because hydraulic valves normally hiss during some modes of operation.

Difficult steering may not always indicate a problem with power steering pressure. For instance, if a vehicle has difficult steering early in the morning when it is cool but does not later in the day when it is warm, then the problem is probably not the pump. The problem is most likely a valve sealing problem within the rack-and-pinion gear.

A pressure test is commonly performed to check the operation of the pump valves in a power steering pump. To perform this test, the fluid must be warm and at the correct level and the belt tension properly adjusted. Procedures, tools used, and specifications will vary from vehicle to vehicle. Some slipper type pumps used in Ford Motor Company products require the use of a special pressure analyzer. Other systems require special connectors and pressure gauges.

Guidelines:

- Make sure the correct type of fluid is in the pump. Some power steering problems are the result of using the wrong fluid.

- Vehicle manufacturers sometimes use power steering pumps produced by one or more other companies. Be sure that the procedure used is the one required for that brand of pump.

- Use the proper gauges and hoses for servicing. Make sure hydraulic lines and hoses are undamaged and free of kinks. Pressures can sometimes be as high as 300 psi during operation of the unit.

- A pressure test should be made with the fluid at the normal operating temperature specified by the manufacturer.

- Most pressure tests require that fluid flow be halted during the test by closing a particular valve in the test equipment. When this is done, the valve should be kept closed for no more than five seconds, or the fluid will overheat.

- Some tests require that readings be taken with the steering wheel turned to one stop and then the other or that the steering wheel be turned from stop to stop at given pressures. When doing these steps, hold the steering wheel at the stops only as long as necessary to get a steady reading, or the pump may be damaged.

- Carefully read the pressure gauges and compare the readings to specifications. The manufacturer will specify readings, ranges, and fluctuation allowances. Be sure that the readings are within limits.

- If losing pressure, check to see if there is a problem with the pump. Pressure loss could also result from a leak elsewhere in the system.

- Should further service be required, be sure to allow the system to cool before disconnecting the hoses or otherwise disassembling the system. Power steering fluid becomes very hot during system testing and can cause serious injury.

- Refill the fluid to the proper level after testing.

EQUIPMENT AND MATERIALS

- Vehicle with power steering
- Appropriate service manual
- Other equipment and materials as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

SERVICE STEERING SYSTEMS

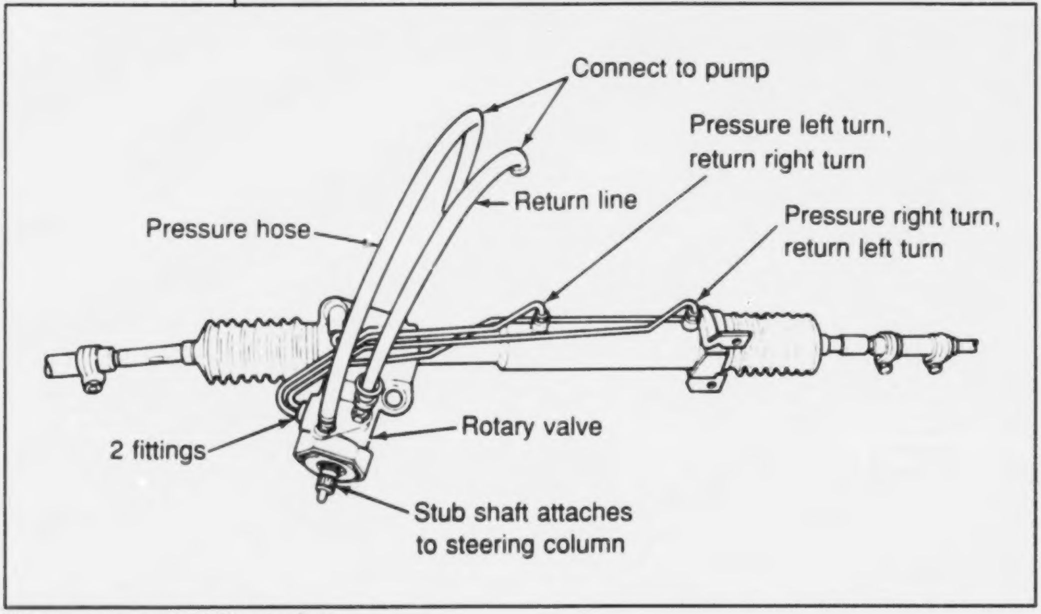
OBJECTIVE 16K

Replace a power rack-and-pinion steering assembly.

INTRODUCTION

The recent popularity of smaller cars and front-wheel drive designs has led to an increase in the number of vehicles with rack-and-pinion steering. Most of those manufactured today also have power-assisted steering. (Figure 1)

FIGURE 1


Connect to pump
Pressure left turn, return right turn
Return line
Pressure hose
Pressure right turn, return left turn
Rotary valve
2 fittings
Stub shaft attaches to steering column

Used with permission of Chrysler Corp.

Since reconditioning a rack-and-pinion steering gear is not cost-effective and sometimes not recommended, a damaged or worn gear is simply replaced. Leaking seals is a common cause for replacement. Control valve seals and rack seals are points where leakage typically occurs. However, seal replacement alone is not usually effective in correcting the problem. Leakage most often occurs because the aluminum housing is badly scored and not because seals are faulty or worn.

If the steering gear is damaged or worn, it is likely that the housing is also damaged. Whenever a power rack-and-pinion steering gear needs to be replaced, the entire steering assembly often must be replaced.

Guidelines:

- Never assume that leakage is an indication of a defective rack or rack seals. Leakage can also be caused by excessive pump pressure. If the system leaks, test the pump before deciding to replace the steering assembly.
- Handle fluid lines carefully to avoid kinking.
- To avoid contamination, cap lines when you disconnect them and leave them capped until you reconnect them.
- Adjust the fluid to the correct level after steering assembly replacement.

EQUIPMENT AND MATERIALS

- Vehicle with a power rack-and-pinion steering assembly
- Appropriate service manual
- Other equipment and materials as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

JOB
SHEET 12

SERVICE STEERING SYSTEMS

II

OBJECTIVE 16L **Recondition a power steering pump.**

INTRODUCTION

Power steering pumps hold up surprisingly well. The pumps are in constant use when the engine is running. They are often run with low fluid levels and incorrect belt tensions, especially on older vehicles. Yet they keep working—for the life of the vehicle in many cases.

Eventually, however, most power steering pumps will develop leaks or lose efficiency. The most common service required is the replacement of seals. This is considered a minor reconditioning. A full reconditioning job would include the inspection and replacement of slippers, vanes, springs, and other parts as required. These procedures can be involved or very involved, depending on the pump design.

One of the most important things to remember when working on a power steering pump is that the reservoir housing is not strong enough to withstand a lot of pressure. Many pump reservoirs have been damaged from being dropped, banged on, or used as a pry point during belt tightening. A damaged reservoir must be replaced.

When reconditioning a power steering pump, always follow the guidelines listed below.

Guidelines:

- Never assume that leakage is an indication of a defective rack or rack seals. Leakage can also be caused by excessive pump pressure. If the system leaks, test the pump before deciding to replace the steering assembly.

- Always use the correct specialty tool when reconditioning a power steering pump. It is important to properly use the pulley puller and the seal installer. If the correct tools are not used, damage or personal injury could occur.

- Follow the correct procedure when reconditioning a pump. Vehicle manufacturers often use more than one model of power steering pump—even on similar model vehicles. These pumps may be one of any of the four kinds of pumps you have studied, and the service technician must be sure to use the appropriate procedure. Most power steering pumps are marked with a label giving information such as model number and date of manufacturer.

EQUIPMENT AND MATERIALS

- Vehicle with power steering
- Appropriate service manual
- Other equipment and materials as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

JOB SHEET 13

SERVICE STEERING SYSTEMS

II

OBJECTIVE 16M **Recondition constant-velocity joints.**

INTRODUCTION

The increased use of front-wheel drive vehicles has led to a large number of vehicles with constant-velocity, or CV, joints. Although CV joints are not a part of the steering system, they must function with the steering and suspension systems if the vehicle is to run correctly. Most suspension and steering technicians will not be called upon to recondition CV joints, because this task is done primarily by transmission/transaxle technicians. However in some repair jobs, the suspension and steering technician may have to recondition these joints. Symptoms of CV joint problems are easily confused with steering and suspension problems.

It is important to properly diagnose constant-velocity joint problems. The service technician should always test drive the vehicle, turn the vehicle, and listen for unusual noises. If a clicking sound can be heard while making turns, there most likely is a problem with the outer CV joint. If vibration is felt during acceleration, there may be a problem with the inner joint.

The suspension and steering technician will need to know how to disconnect and reconnect front drive axle parts just to do some of the service required. He or she may also be called upon to do the most common CV joint service required—replacing damaged or leaking bellows boots. Not only is the procedure similar to the replacement of boots on rack-and-pinion steering systems, but the requirement for such service is often discovered while suspension or steering service is being performed.

Guidelines:

- Several different types of CV joints are used on vehicle drive axles. Sometimes the type of joints used may vary, even on the same make and model vehicle. Be careful to select the correct service for the type of joints in use.
- Be sure to check the vehicle manufacturer's manual to see if the CV joint can be reconditioned. Some joints may be rebuilt, while others must be replaced as an assembly.
- If the housing is damaged, always replace the joint as a unit.

- Support both ends of the assembly during removal and installation. Do not allow the assembly to hang at either end.

- Always use the specified lubricant. Lubricant that is made especially for CV joints is often included in the joint replacement kit.

- Place the entire assembly in the vise when replacing the joint assembly or the boot. Use care to avoid damaging the shaft.

- Tighten clamps first by hand, then complete installation by tightening them with the appropriate clamp tool.

- Use the correct gasket when reinstalling the differential cover.

EQUIPMENT AND MATERIALS

- Front-wheel drive vehicle
- Appropriate service manual
- Other equipment and materials as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

SERVICE STEERING SYSTEMS

JOB SHEET 1

Inspect and replace steering column components.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Prepared the vehicle and work area appropriately.	_____	_____
3. Inspected all parts following manufacturer's instructions.	_____	_____
4. Inspected and replaced defective steering column parts following procedures in the manufacturer's service manual.	_____	_____
5. Followed the guidelines outlined in the job sheet.	_____	_____
6. Completed service correctly.	_____	_____
7. Observed safety rules and precautions.	_____	_____
8. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

SERVICE STEERING SYSTEMS

JOB SHEET 2

Inspect and replace a pitman arm.

STUDENT'S NAME ____________________ DATE ____________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Prepared the vehicle and work area appropriately.	_____	_____
3. Inspected pitman arm following outlined procedure.	_____	_____
4. Removed pitman arm following procedure outlined in vehicle manufacturer's service manual.	_____	_____
5. Installed new pitman arm following outlined procedure.	_____	_____
6. Completed service and Wheel Alignment Checksheet correctly.	_____	_____
7. Observed safety rules and precautions.	_____	_____
8. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 3

Inspect, replace or repair, and install an idler arm and mounting.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	______	______
2. Prepared the vehicle and work area appropriately.	______	______
3. Inspected idler arm and support following outlined procedure.	______	______
4. Removed and replaced or repaired and reinstalled idler arm with threaded bushing.	______	______
5. Removed and replaced or repaired and reinstalled idler arm with rubber-torsion bushing.	______	______
6. Removed and replaced idler arm with ball-and-socket connection.	______	______
7. Completed service and Wheel Alignment Checksheet correctly.	______	______
8. Observed safety rules and precautions.	______	______
9. Cleaned work area and returned equipment and materials to proper storage.	______	______

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 4

Inspect and replace a center link.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	______	______
2. Prepared the vehicle and work area appropriately.	______	______
3. Inspected center link correctly.	______	______
4. Replaced center link following procedure given in vehicle manufacturer's service manual.	______	______
5. Followed guidelines outlined in the job sheet.	______	______
6. Completed service correctly.	______	______
7. Observed safety rules and precautions.	______	______
8. Cleaned work area and returned equipment and materials to proper storage.	______	______

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 5

Inspect and replace a tie-rod assembly.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	______	______
2. Prepared the vehicle and work area appropriately.	______	______
3. Inspected tie-rod ends following outlined procedure.	______	______
4. Removed and replaced tie-rod assembly (parallelogram linkage) following outlined procedure.	______	______
5. Removed and replaced tie-rod assembly (rack-and-pinion linkage) following procedure outlined in vehicle manufacturer's service manual.	______	______
6. Completed service correctly.	______	______
7. Observed safety rules and precautions.	______	______
8. Cleaned work area and returned equipment and materials to proper storage.	______	______

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 6

Inspect and replace steering damper.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	______	______
2. Prepared the vehicle and work area appropriately.	______	______
3. Inspected steering damper following procedure given in vehicle manufacturer's service manual.	______	______
4. Removed steering damper following procedure in vehicle manufacturer's service manual.	______	______
5. Replaced steering damper following procedure in vehicle manufacturer's service manual.	______	______
6. Followed guidelines outlined in job sheet.	______	______
7. Completed service correctly.	______	______
8. Observed safety rules and precautions.	______	______
9. Cleaned work area and returned equipment and materials to proper storage.	______	______

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 7

Adjust, or replace and adjust, a power recirculating-ball type steering gear.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Prepared the vehicle and work area appropriately.	_____	_____
3. Correctly adjusted worm bearing preload following procedure outlined in vehicle manufacturer's service manual.	_____	_____
4. Correctly adjusted sector shaft end play following procedure outlined in vehicle manufacturer's service manual.	_____	_____
5. Replaced steering gear following procedure outlined in vehicle manufacturer's service manual.	_____	_____
6. Completed service correctly.		
7. Observed safety rules and precautions.	_____	_____
8. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

____

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 8

Inspect and replace a bellows boots.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	______	______
2. Prepared the vehicle and work area appropriately.	______	______
3. Inspected boot correctly.	______	______
4. Replaced bellows boots following procedure given in vehicle manufacturer's service manual.	______	______
5. Followed guidelines outlined in the job sheet.	______	______
6. Completed service correctly.	______	______
7. Observed safety rules and precautions.	______	______
8. Cleaned work area and returned equipment and materials to proper storage.	______	______

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 9

Replace a manual-rack-and-pinion steering gear.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	______	______
2. Prepared the vehicle and work area appropriately.	______	______
3. Removed steering gear following procedure given in vehicle manufacturer's service manual.	______	______
4. Installed new steering gear following procedure outlined in vehicle manufacturer's service manual.	______	______
5. Followed guidelines outlined in the job sheet.	______	______
6. Completed service correctly.	______	______
7. Observed safety rules and precautions.	______	______
8. Cleaned work area and returned equipment and materials to proper storage.	______	______

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 10

Perform a power steering pressure test.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	______	______
2. Prepared the vehicle and work area appropriately.	______	______
3. Performed power steering pressure test following procedure given in vehicle manufacturer's service manual.	______	______
4. Correctly used tools and equipment specified in vehicle manufacturer's service manual.	______	______
5. Followed procedures outlined in the job sheet.	______	______
6. Completed service correctly.	______	______
7. Observed safety rules and precautions.	______	______
8. Cleaned work area and returned equipment and materials to proper storage.	______	______

EVALUATOR'S COMMENTS

____

____

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PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 11

Replace a power rack-and-pinion steering assembly.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	______	______
2. Prepared the vehicle and work area appropriately.	______	______
3. Replaced assembly following procedures given in vehicle manufacturer's service manual.	______	______
4. Correctly used tools and equipment specified in vehicle manufacturer's service manual.	______	______
5. Followed guidelines outlined in the job sheet.	______	______
6. Completed service correctly.	______	______
7. Observed safety rules and precautions.	______	______
8. Cleaned work area and returned equipment and materials to proper storage.	______	______

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

SERVICE STEERING SYSTEMS

JOB SHEET 12

Recondition a power steering pump.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	______	______
2. Prepared the vehicle and work area appropriately.	______	______
3. Reconditioned power steering pump following procedure given in vehicle manufacturer's service manual.	______	______
4. Followed guidelines outlined in the job sheet.	______	______
5. Completed service correctly.	______	______
6. Observed safety rules and precautions.	______	______
7. Cleaned work area and returned equipment and materials to proper storage.	______	______

EVALUATOR'S COMMENTS

____

____

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PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

____

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TESTS

SERVICE STEERING SYSTEMS

II

JOB SHEET 13

Recondition constant-velocity joints.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	______	______
2. Prepared the vehicle and work area appropriately.	______	______
3. Correctly determined needed service.	______	______
4. Reconditioned CV joint following procedure given in vehicle manufacturer's service manual.	______	______
5. Followed guidelines outlined in the job sheet.	______	______
6. Completed service correctly.	______	______
7. Observed safety rules and precautions.	______	______
8. Cleaned work area and returned equipment and materials to proper storage.	______	______

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

WRITTEN TEST

SERVICE STEERING SYSTEMS

II

NAME ______________________ SCORE ________

OBJECTIVE 1

Select definitions of terms associated with wheel bearings. Choose the definitions that best define the following terms and write the correct letters in the blanks.

______1. **constant-velocity (CV) joint**

A. Part of a wheel spindle assembly connecting the ball joints; turns to steer the wheel
B. Part of a parallelogram steering linkage that maintains proper toe
C. Part of the steering system connecting the steering shaft and the steering linkage; changes rotary motion to side-to-side motion for steering
D. Joint used in a driveline so that output driveshaft speed equals input driveshaft speed

______2. **steering ratio**

A. Various angles formed by the relationship among the suspension system parts, the front wheels, and the ground
B. A numerical ratio representing the number of turns made by the worm shaft to turn the sector shaft once
C. Ratio of the length of the steering shaft to the length of the driveshaft
D. Ratio of the vehicle's speed to the distance a vehicle travels before turns are completed

______3. **rack-and-pinion steering linkage**

A. Steering system components designed so that steering wheel motion is transferred to the wheels through a linkage consisting of a pinion gear, rack, and tie-rod assemblies
B. Steering system designed so that steering wheel motion is transferred to the wheels through a linkage consisting of a pitman arm, idler arm, center link, and tie-rod assemblies
C. System which uses hydraulic pressure to assist steering wheel turning effort
D. Steering system in which steering wheel motion is transmitted mechanically with no power assist

______4. **parallelogram steering linkage**

A. Steering system components designed so that steering wheel motion is transferred to the wheels through a linkage consisting of a pitman arm, idler arm, center link, and tie-rod assemblies
B. Steering system components designed so that steering wheel motion is transferred to the wheels through a linkage consisting of a pinion gear, rack, and tie-rod assemblies
C. System in which steering motion is transmitted mechanically with no power assist
D. Steering system which uses hydraulic pressure from a pump to assist steering wheel effort

______5. **steering geometry**

A. Relationship between the path of the front tires and the path of the rear tires
B. Number of degrees that a steering wheel must be turned to turn wheels one degree
C. Angle formed between a vertical line extending through the wheel and a horizontal line extending through the driveshaft
D. Various angles formed by the relationship among the suspension system parts, the front wheels, and the ground

______6. **center link**

A. Rod connecting the center hub to the axle on both wheels
B. Rod connecting the steering wheel to the steering gearbox; transfers steering movement from the steering wheel to the steering gear
C. Rod connecting the rack to the steering knuckle; transfers steering movement from the pinion gear to both sides of the vehicle
D. Rod connecting the pitman and idler arms to the tie-rods; transfers steering movement from the pitman arm to both sides of the vehicle

______7. **idler arm**

A. Part supporting the end of the center link opposite the pitman arm; keeps the center link parallel to the road surface to maintain proper toe
B. Part connecting the steering gear to the center link; transfers the rotating motion of the sector shaft to side-to-side motion at the center link
C. Steering linkage component which prevents wheel movement when the vehicle is idling
D. Rod connecting the steering wheel to the steering gear

______8. **pitman arm**

A. Part supporting the end of the center link opposite the idler arm; is mounted between the center link and the vehicle frame
B. Part connecting the pitman shaft to the steering shaft
C. Part connecting the steering gear to the center link; transfers the rotating motion of the sector shaft to side-to-side motion at the center link
D. Part connecting the steering gear to the vehicle frame

______9. **steering knuckle (arm)**

A. Hard rubber covering on a CV joint which protects the joint from damage
B. Part of a wheel spindle assembly connecting the ball joints
C. Part of the wheel spindle assembly connecting the steering gear to the wheel; guards against over-steering
D. The hard rubber part of the wheel spindle assembly that protects it from damage

______10. **steering linkage**

A. Assembly connecting the steering gear and the front wheels; transmits motion from the steering gear to the steering knuckle
B. Driveline component consisting of two coupled universal joints that allows the driveshaft input speed to equal the driveshaft output speed
C. System of joints connecting the tie-rod assembly to the steering knuckle
D. Driveline component consisting of two coupled universal joints arranged so that output driveshaft speed equals input driveshaft speed

______11. **steering gear**

A. Part of the steering system connecting the steering shaft and idler arm; changes side-to-side motion to rotary motion for steering
B. Part connecting the steering shaft to the pitman shaft; changes side-to-side motion to rotary motion for steering
C. Driveline component consisting of two coupled universal joints arranged so that output driveshaft speed equals input driveshaft speed
D. Part of the steering system connecting the steering shaft and the steering linkage; changes rotary motion to side-to-side motion for steering

______12. **steering column**

A. Component housing the sector shaft and the wormshaft
B. Component housing the steering shaft and supporting accessory controls
C. Rod connecting the steering wheel to the steering gearbox
D. Component housing the steering gearbox and the wormshaft

_____13. **steering shaft**

A. Component connecting the sector shaft and the wormshaft
B. Rod connecting the steering wheel to the steering gear
C. Component connecting the steering gear and the steering knuckle; changes rotary motion to side-to-side motion for steering
D. Rod connecting the steering wheel to the steering gearbox

_____14. **power steering system**

A. System which uses hydraulic pressure from a pump to assist steering wheel turning effort
B. System which is designed so that steering wheel motion is transferred directly to the wheels by a power pump
C. System in which steering motion is transmitted mechanically with no power assist
D. System which uses hydraulic pressure from a pump to assist wormshaft action

_____15. **manual steering system**

A. System which uses hydraulic pressure from a pump to assist steering wheel turning effort
B. System which is designed so that steering wheel motion is transferred directly to the wheels
C. System in which steering motion is transmitted mechanically with no power assist
D. System in which steering motion is transferred from the steering wheel to the steering gearbox by a pitman arm

_____16. **gear ratio**

A. A numerical ratio representing the number of turns made by the drive gear to complete one turn of the driven gear
B. The number of revolutions the driving gear completes per minute
C. The number of revolutions the driving gear completes per unit of energy used
D. The number of revolutions the driven gear completes before the driving gear completes one revolution

OBJECTIVE 2 **State the purposes of the steering system.**

1. ____
____

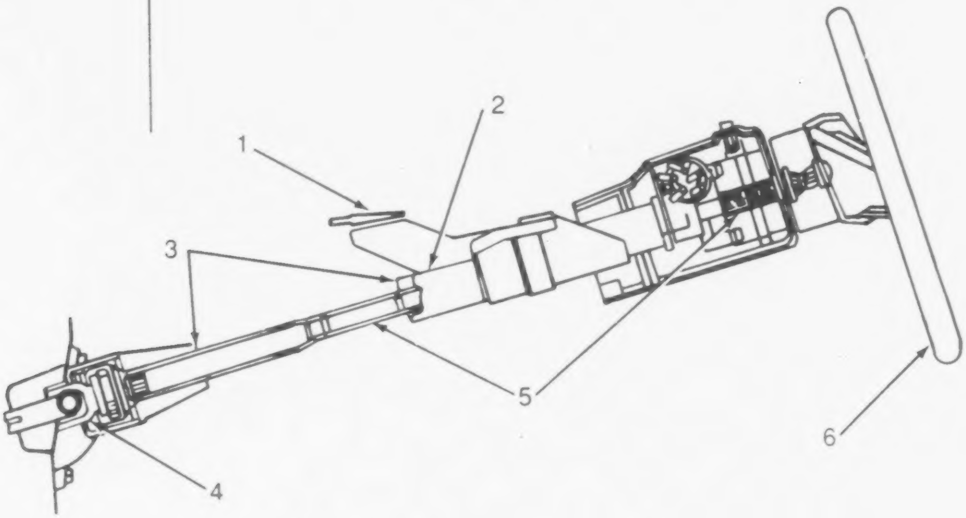
2. ____
____

3. ____
____

4. ____
____

OBJECTIVE 3

Label the parts of a collapsible steering column. Put the letter of the part indicated in the blank.



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_______1. A. Collapsible section

_______2. B. Dash mount

_______3. C. Steering column

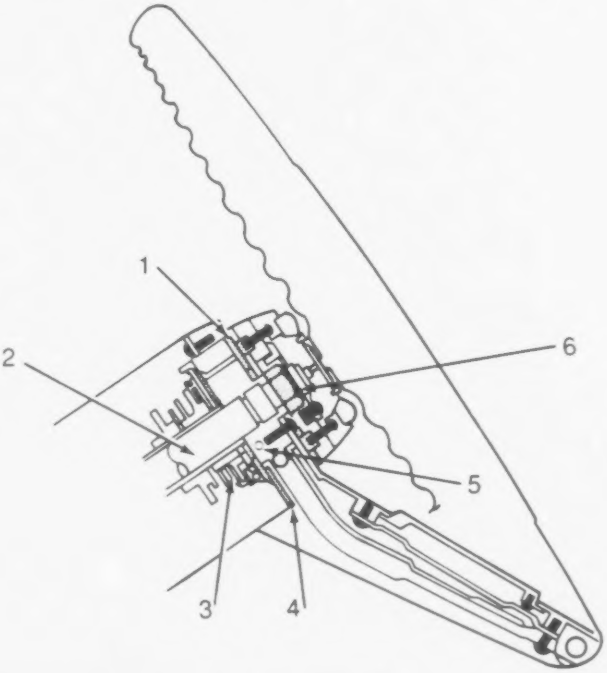
_______4. D. Steering shaft

_______5. E. Steering wheel

_______6. F. Universal joint or flexible coupling

OBJECTIVE 4

Label the parts of a steering wheel assembly with tilting capabilities. Put the letter of the part indicated in the blank.



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______1. A. Horn ring

______2. B. Lock plate

______3. C. Steering shaft

______4. D. Steering wheel nut

______5. E. Tilt spring

______6. F. Turn signal switch

OBJECTIVE 5

Match the elements of front-end geometry to their descriptions. Write the correct letters in the blanks.

______1. The alignment of the rear wheels with the front wheels

______2. The relationship of the distances between both wheels on an axle measured at both the front and the back of the wheels

______3. The tilt of the top of the tire and wheel assembly inward or outward when compared to a vertical line extending from center of the bottom of the assembly

______4. The total angle from the inside of the SAI angle to the outside of the camber angle

______5. The angle between vertical and a line running through the centers of the upper and lower pivot points of the steering support when viewed from the front

______6. The difference between the two angles of the front wheels relative to the vehicle when the vehicle is turning

______7. The angle between vertical and a line running through the centers of the upper and lower pivot points of the steering support when viewed from the side

A. Camber

B. Caster

C. Steering axis inclination (SAI)

D. Included angle

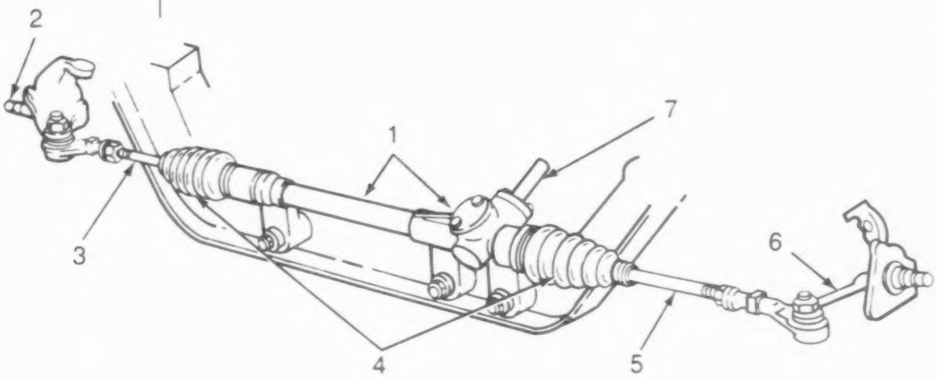
E. Toe

F. Turning radius

G. Tracking

OBJECTIVE 6 **Label the parts of steering linkage designs.** Put the letter of the part indicated in the blank. Some words may be used more than once.

Rack-and-pinion linkage



Adapted with permission of Ford Motor Co.

______1.

______2.

______3.

______4.

______5.

______6.

______7.

A. Bellows boots

B. Pinion shaft

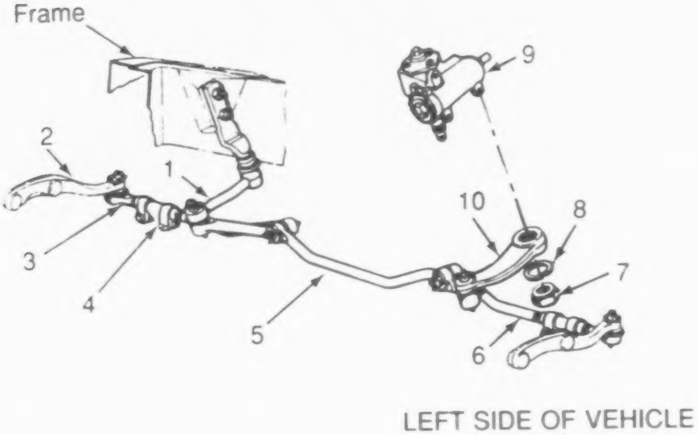
C. Spindle

D. Steering arm

E. Steering gear

F. Tie-rod

Parallelogram linkage


Frame
9
2
1
10
8
7
3
4
5
6
LEFT SIDE OF VEHICLE

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______1.

______2.

______3.

______4.

______5.

______6.

______7.

______8.

______9.

______10.

A. Adjuster sleeve

B. Center link

C. Idler arm

D. Pitman arm

E. Retaining nut

F. Steering arm

G. Steering gear

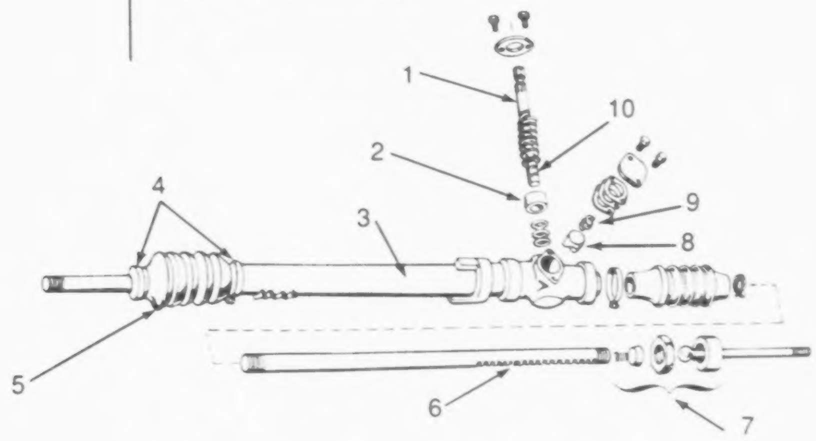
H. Tie-rod

I. Tie-rod end

J. Washer

OBJECTIVE 7 **Label the parts of steering gears.** Put the letter of the part indicated in the blank. Some words may be used more than once.

Rack-and-pinion type



Used with permission of Moog Automotive, Inc.

_______1. A. Adjuster spring

_______2. B. Bearing

_______3. C. Bellows boot

_______4. D. Bellows clamps

_______5. E. Housing

_______6. F. Inner ball socket assembly

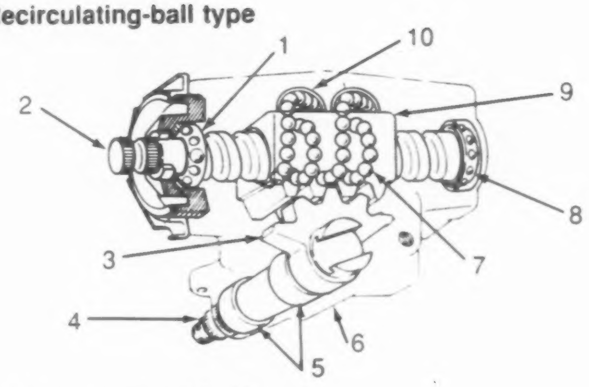
_______7. G. Pinion gear

_______8. H. Pinion shaft

_______9. I. Rack

_______10. J. Support yoke

Recirculating-ball type



Used with permission of Ford Motor Co.

______1. A. Ball nut

______2. B. Bearing

______3. C. Gear sector

______4. D. Guides

______5. E. Housing

______6. F. Recirculating balls

______7. G. Sector shaft

______8. H. Worm shaft

______9.

______10.

OBJECTIVE 8

Match power steering system components to their functions.
Write the correct letters in the blanks.

_______1. Senses the amount of steering effort being applied and opens or closes ports to direct the fluid to the power piston from the pump

_______2. Transmits force from the pump to the steering linkage

_______3. Carries the fluid (under pressure) between the parts of the power steering system

_______4. Delivers fluid under pressure to the control valve

_______5. Transmits the force of the fluid from the control valve to the steering linkage

_______6. Prevents heat damage to hoses and seals by lowering the fluid temperature in air-conditioned vehicles

_______7. Holds the power steering fluid; usually is part of the power steering pump

A. Control valve

B. Fluid cooler

C. Hoses

D. Power cylinder

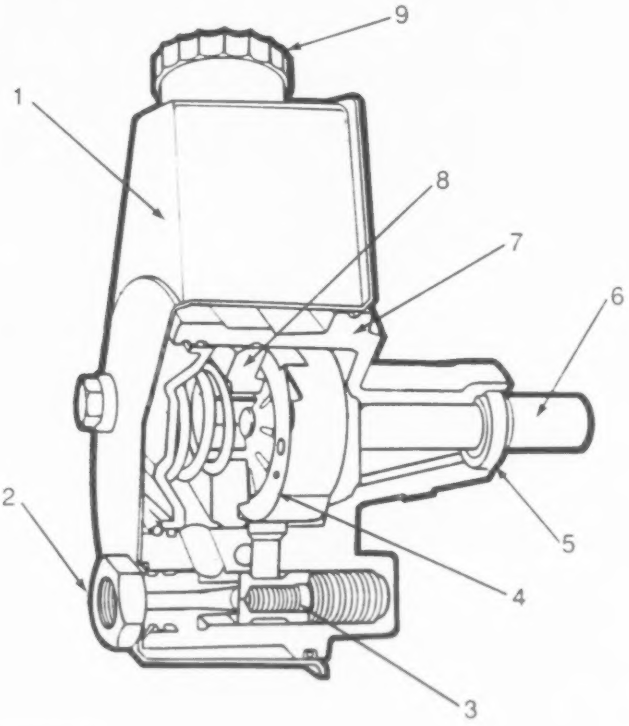
E. Power steering fluid

F. Power steering pump

G. Reservoir

OBJECTIVE 9

Label the parts of a power steering pump. Put the letter of the part indicated in the blank. Some words may be used more than once.



Used with permission of Ford Motor Co.

______1. A. Driveshaft

______2. B. Filler plate

______3. C. Flow control valve

______4. D. Oil reservoir

______5. E. Pressure outlet

______6. F. Pressure plate

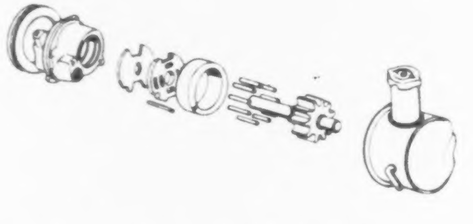
______7. G. Pump housing

______8. H. Rotor and vanes

______9. I. Shaft seal

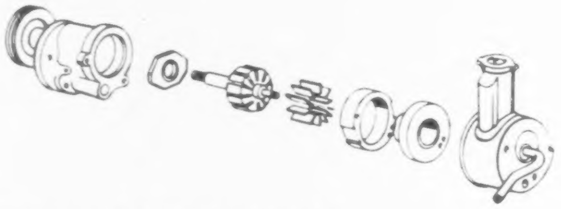
OBJECTIVE 10

Identify types of power steering pumps. Write the correct names in the blanks below the illustrations.



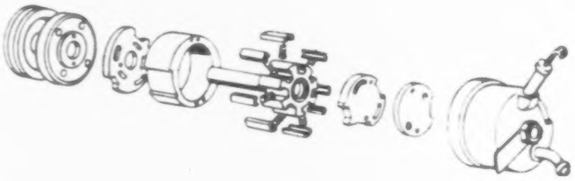
Used with permission of Moog Automotive, Inc.

1. ______________________________



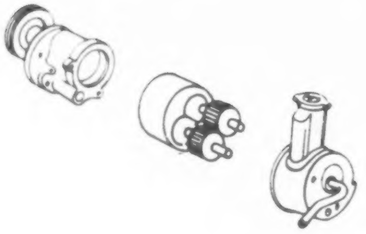
Used with permission of Moog Automotive, Inc.

2. ______________________________



Used with permission of Moog Automotive, Inc.

3. ______________________________



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4. ______________________________

OBJECTIVE 11

Describe types of power steering systems. Write a description of each of the following types of power steering systems.

1. **Linkage-booster** — ______________________________

____

____

____

____

2. **Integral** — ______________________________

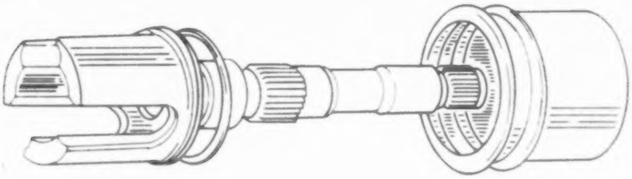
____

____

____

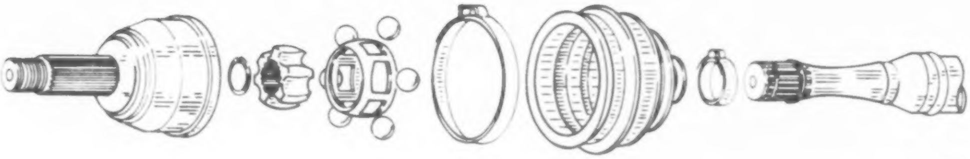
____

OBJECTIVE 12 **Identify types of constant-velocity joints.** Write the correct names in the blanks below the illustrations.



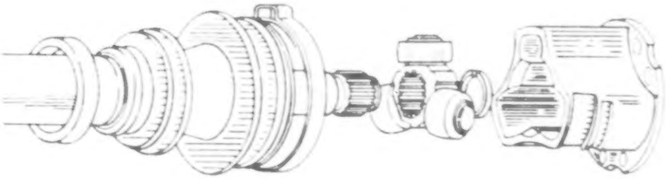
Used with permission of Dana Corp., Perfect Circle Products

1. ______________________________



Used with permission of Dana Corp., Perfect Circle Products

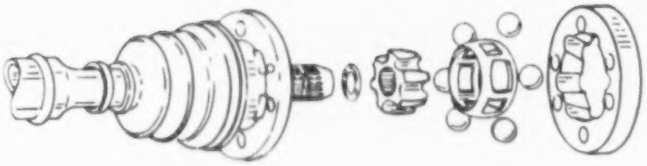
2. ______________________________



Used with permission of Dana Corp., Perfect Circle Products

3. ______________________________

237



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4. ____________________

WRITTEN TEST ANSWERS

SERVICE STEERING SYSTEMS

II

OBJECTIVE 1

1. D
2. B
3. A
4. A
5. D
6. D
7. A
8. C
9. B
10. A
11. D
12. B
13. B
14. A
15. C
16. A

OBJECTIVE 2

The answer should include *all* of the following:

- To allow the driver to position the wheels
- To allow the turning of the front wheels with reasonable effort
- To maintain the correct relationship between the front wheels while the vehicle is moving
- To transmit the feel of the road surface to the driver

OBJECTIVE 3

1. B
2. C
3. A
4. F
5. D
6. E

OBJECTIVE 4

1. A
2. C
3. E
4. B
5. F
6. D

OBJECTIVE 5

1. G
2. E
3. A
4. D
5. C
6. F
7. B

OBJECTIVE 6

Rack-and-pinion linkage

1. E
2. C
3. F
4. A
5. F
6. D
7. B

Parallelogram linkage

1. C
2. F
3. I
4. A
5. B
6. H
7. E
8. J
9. G
10. D

OBJECTIVE 7

Rack-and-pinion type

1. H
2. B
3. E
4. D
5. C
6. I
7. F
8. J
9. A
10. G

Recirculating-ball-type

1. B
2. H
3. C
4. G
5. B
6. E
7. F
8. B
9. A
10. D

OBJECTIVE 8

1. A
2. E
3. C
4. F
5. D
6. B
7. G

OBJECTIVE 9

1. D
2. E
3. C
4. H
5. I
6. A
7. G
8. F
9. B

OBJECTIVE 10

1. Roller
2. Vane
3. Slipper
4. Rotor (gear)

OBJECTIVE 11

1. System in which a separate power cylinder is attached to the linkage and the control valve is not located within the steering gear housing
2. System in which the power piston and the control valve are located within the steering gear housing

OBJECTIVE 12

1. Tripod joint (with open tulip housing)
2. Fixed Rzeppa joint
3. Tripod joint (with closed tulip housing)
4. Rzeppa plunging joint (cross groove joint)

OBJECTIVE SHEET

SERVICE FRONT SUSPENSION SYSTEMS III

INTRODUCTION

Before the steering and suspension technician aligns the front end of a vehicle, he or she must make sure that the vehicle's suspension system is in good condition. Bent, broken, or damaged front suspension system components and parts can interfere with alignment setting procedures, sometimes even making it impossible to perform and maintain an accurate alignment. Missing or damaged front suspension system components can cause the passengers to have an uncomfortable ride and the vehicle to handle poorly and unsafely.

PREREQUISITES

Before studying this unit, the student should have successfully completed Unit 2, *Service Steering Systems.*

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose front suspension system problems and service common front suspension systems. The student will demonstrate these competencies by completing the assignment sheet, job sheets, and written test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to:

1. Select the definitions of terms associated with front suspension system service.
2. State the purposes of a front suspension system.
3. List the types of springs used in front suspension systems.
4. Describe the types of front suspension systems.
5. Label the parts of a short-and-long-arm suspension system.
6. Label the parts of a twin I-beam suspension system.
7. Label the parts of a MacPherson strut suspension system.
8. Label the parts of torsion bar suspension systems.
9. Match front suspension system parts to their purposes.
10. State the functions of load-carrying and non-load-carrying ball joints.

11. Label the parts of a shock absorber.

12. Match the types of shock absorbers to their uses.

13. Describe the types of adjustable leveling suspension systems.

14. Diagnose front suspension system problems. (Assignment Sheet 1)

15. Demonstrate the ability to:

    A. Inspect short-and-long-arm coil spring suspension system components. (Job Sheet 1)

    B. Repair a short-and-long-arm suspension system. (Job Sheet 2)

    C. Inspect, replace, and adjust front suspension system torsion bars. (Job Sheet 3)

    D. Inspect and replace the stabilizer bar, bushings, brackets, and links. (Job Sheet 4)

    E. Inspect a twin I-beam suspension system. (Job Sheet 5)

    F. Inspect, remove, and replace MacPherson strut type suspension system components. (Job Sheet 6)

PREPARATION

- Review the unit and plan the presentation. Study the specific objectives to determine the order in which you will present the objectives.

- Many multiple-choice test questions (in the Pretests, Assignment Sheets, and Written Test) for this curriculum have been written in a style that is similar to the questions on the ASE certification test. Like ASE questions, the student should select the item that **BEST** answers the question. *The student should make no additional assumptions about a question other than those specifically given in the question.* A special effort has been made to provide good distracters for each question which will make the student think through the answer. It is suggested that the instructor review the answers to every test before reviewing the test with the students so that he or she is not caught off guard by such distracters.

- Review the teaching suggestions given in the Delivery and Application sections and plan classroom activities.

- Plan the presentation to take advantage of student learning styles and accommodate students with special needs.

- Obtain films, videotapes, and other media to supplement the instruction of this unit. See ordering information in the Suggested Resources section. Include in your selection media that demonstrate job sheet skills. Videotape your own demonstrations of job sheet procedures if you area unable to obtain suitable media.

- Obtain competency profiles.

  NOTE: Competency profiles for this book are available from the Curriculum and Instructional Materials Center, Oklahoma Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364.

- Prepare the classroom and shop. Display posters, charts, safety signs, etc. that emphasize front suspension system service. Have articles, specification guides, mock-ups, and other references about suspension-system service available for student use.

- Discuss the purpose of pretesting with the students. Explain that they will be asked to complete a written pretest and that they will be required to demonstrate assignment sheet competencies and job sheet skills as part of the pretesting process.

- Provide the students with the equipment and materials necessary to complete the pretest. Administer the pretest.

- Assess student competencies. Consider the results of student assessments as you prepare your presentation for each objective.

DELIVERY

Unit introduction

- Discuss the introduction to the unit. (See Objective Sheet.)

- Discuss the unit objective and then the specific objectives. Emphasize how accomplishing the specific objectives will lead to meeting the unit objective and how reaching the unit objective is vital to becoming an automotive steering and suspension technician. Also, relate the objective to your introduction and to material previously covered.

Objective 1 Select the definitions of terms associated with front suspension system service.

- Show the students examples of as many of the terms listed in this objective as possible.

- Explain the difference between *sprung weight* and *unsprung weight*. List examples of parts that are sprung weight and those that are unsprung weight.

- Refer the students to the types of suspension systems illustrated in Objective 4. Point out the suspension components that are defined in this objective.

- Discuss the terms *jounce* and *rebound* and emphasize that the two terms are not interchangeable.

Objective 2 State the purposes of a front suspension system.

- Discuss each of the purposes listed in this objective. Ask the students if they can think of examples for each of these purposes.

Objective 3 List the types of springs used in front suspension systems.

- Discuss each of the four types of springs and list examples of suspension systems using each type.
- Ask the students to list particular vehicle models that use each type of spring.
- Explain to the students how each type absorbs road shock and supports vehicle weight.
- Show the film, *It's Coil Spring Time.*

Objective 4 Describe the types of front suspension systems.

- Discuss each type presented and point out whether each is independent or non-independent.
- Discuss the advantages of each system and the types of vehicles that use them.
- Use Transparency Masters 4-8 to expand your discussion.
- Show the slide presentation, *Front and Rear Suspension Systems.*

Objective 5 Label the parts of a short-and-long-arm suspension system.

Objective 6 Label the parts of a twin I-beam suspension system.

- Show the filmstrip, *Twin I-Beam Front Suspension.*

Objective 7 Label the parts of a MacPherson strut suspension system.

- Show the film, *There's a Need to Know About MacPherson Struts.*

Objective 8 Label the parts of torsion bar suspension systems.

- Discuss the components and parts of the suspension systems presented in Objectives 5, 6, 7, and 8.

- Take the students to the shop and have them identify the different suspension parts on each vehicle.

- Combine this objective with Objective 9, pointing out each component and explaining its purpose.

Objective 9 Match front suspension system parts to their purposes.

- Discuss the purpose of each part. Explain how each part accomplishes its purpose.

Objective 10 State the functions of load-carrying and non-load-carrying ball joints.

- Show the students a ball joint and explain how it works.

- Explain the difference between load-carrying and non-load-carrying joints and how to determine whether a ball joint is load-carrying or not.

- Review the boxed material, "More About Ball Joints," with the students.

Objective 11 Label the parts of a shock absorber.

- Discuss the different parts of a shock absorber and describe the purpose or function of each.

- Show the students a shock absorber and explain its operation.

Objective 12 Match the types of shock absorbers to their uses.

- Discuss the four types of shock absorbers presented in this objective and explain the use of each.

- Display each of the types for students to examine.

- Discuss which types may be available on new vehicles and which are not.

Objective 13 Describe the types of adjustable leveling suspension systems.

- Discuss manual and automatic leveling suspension systems and explain the differences between the two types.
- List the types of vehicles that use each type of leveling system.
- Explain how air shocks or air springs are used in these systems.
- Discuss the boxed material, "Leveling Systems."

APPLICATION

Objective 14 Diagnose front suspension system problems. (Assignment Sheet 1)

- Show the films, *Under Car Inspection Pays Off*, and *Doin' It Right*.
- Have students use Supplement 1, Troubleshooting Front Suspension System Problems, to complete Assignment Sheet 1.
- Give each student a service manual and have them locate the suspension troubleshooting charts or diagnostic tables.
- Explain why steering and suspension diagnostic tables are often combined.
- Discuss the terms *wheel tramp*, *shimmy*, *body roll*, and *body dive*. Explain how a vehicle ride feels to the driver when the vehicle's suspension "bottoms" or when the ride is "too soft" or "too hard."
- Have the students read Student Supplement 1, Troubleshooting Front Suspension System Problems, and discuss it in class.
- Discuss the problems found in MacPherson strut suspensions that are not found in short-and-long-arm systems.
- Discuss the introduction to Assignment Sheet 1. Have the students complete Assignment Sheet 1. When all students have completed the assignment, discuss it in class.

Objective 15A Inspect short-and-long-arm coil spring suspension system components. (Job Sheet 1)

- Explain to the students how a wheel alignment check sheet is used—both during an inspection and during service.

- Demonstrate checking shock absorber operation by using the bounce method. Have the students refer to *Introduction to Automotive Service*, Unit B-2, *Remove and Install Common Fasteners*, Job Sheet 6.

- Display ball joints having wear indicators. Include in your display both new and worn ball joints. Point out to the students how the wear indicator on the worn ball joint is flush with or inside the bottom plate.

- Discuss *radial* and *axial* movement. Explain how a dial indicator is used and show the students radial and axial movement specifications in different service manuals.

- Show the students Transparency 1, Jack-Stand Placement for Checking Ball Joints, and discuss why it is necessary to place the stands correctly when checking ball joints.

- Discuss the equipment and materials used in Job Sheet 1. Review applicable safety rules and precautions and the guidelines given in the job sheet introduction.

- Demonstrate Job Sheet 1. Have the students practice Job Sheet 1 until they are ready to take the practical test.

Objective 15B Repair a short-and-long-arm suspension system. (Job Sheet 2)

- Review the procedures for removing the brake caliper and disc or brake drum and hub assembly with the students. Also review wheel bearing adjustment procedures. Have the students refer to the job sheets in Unit 1, *Service Wheel Bearings*, if necessary.

- Review the procedures for removing and installing shock absorbers. Use Transparency 2, Shock Absorber Installation, and discuss how shock absorbers are mounted.

- Show the students different tools used when compressing coil springs. Demonstrate how compressing tools and clips are used. Emphasize the importance of using these tools correctly and safely.

- Show the students a set of coil springs, pointing out the proper installation.

- Display control arms having ball joints that are riveted, bolted, or pressed into place. Discuss the removal procedures for each type.

- Discuss the equipment and materials used in Job Sheet 2. Review applicable safety rules and precautions and the guidelines given in the job sheet introduction.

- Demonstrate Job Sheet 2. Have the students practice Job Sheet 2 until they are ready to take the practical test.

Objective 15C Inspect, replace, and adjust front suspension system torsion bars. (Job Sheet 3)

- Discuss instances when torsion bars must be replaced. For example, torsion bars on a vehicle that has been involved in a front-end collision may need to be replaced because the bars are bent.

- Tell the students that although torsion bar replacement is not a very common service, it is important to understand this procedure because the torsion bars have to be removed and reinstalled whenever control arms are replaced.

- Show the students actual replacement torsion bars. Point out how they are marked for use on the right or the left side.

- Discuss the similarities and differences between transverse and longitudinal torsion bar replacement procedures.

- Use Transparency 3, Torsion Bar Adjustment, to explain how torsion bar adjustment changes vehicle height.

- Discuss the equipment and materials used in Job Sheet 3. Review applicable safety rules and precautions and the guidelines given in the job sheet introduction.

- Demonstrate Job Sheet 3. Have the students practice Job Sheet 3 until they are ready to take the practical test.

Objective 15D Inspect and replace the stabilizer bar, bushings, brackets, and links. (Job Sheet 4)

- Explain how the stabilizer bar helps control body roll.
- Discuss how the stabilizer is attached and point out where bushings are used.
- Discuss the equipment and materials used in Job Sheet 4. Review applicable safety rules and precautions and the guidelines given in the job sheet introduction.
- Demonstrate Job Sheet 4. Have the students practice Job Sheet 4 until they are ready to take the practical test.

Objective 15E Inspect a twin I-beam suspension system. (Job Sheet 5)

Objective 15F Inspect, remove, and replace MacPherson strut type suspension system components. (Job Sheet 6)

- Show the film, *MacPherson Struts*, and the slide show, *MacPherson Strut and Rack and Pinion*.
- Discuss camber and caster. Explain that camber may or may not be adjustable on MacPherson strut systems and explain why caster is not adjustable. Tell the students that although these may not be adjustable, they should always be checked when aligning the front wheels. Point out that improper caster found during an alignment check may indicate a bent strut.
- Discuss the differences in MacPherson struts and modified MacPherson struts. List examples of vehicles with each type.
- Discuss the basic ways to correct strut problems: repairing the strut assembly, repairing by installing a replacement strut cartridge, and replacing the strut assembly.
- Use Transparency 4, Exploded View of a MacPherson Strut, to show the students the many parts of a strut. Explain the purpose of each part.
- Discuss the equipment and materials used in Job Sheet 6. Review applicable safety rules and precautions and the guidelines given in the job sheet introduction.

- Demonstrate Job Sheet 6. Have the students practice Job Sheet 6 until they are ready to take the practical test.

Unit summary activity

- Discuss Activity Sheet 1, Answer General Questions About Front Suspension Systems. The purpose of the activity is to provide the students with the opportunity to practice answering questions similar in content and style to those found on the actual ASE certification test. Keep this in mind when discussing the assignment.
- Have students complete Activity Sheet 1.

EVALUATION

- Give the written test.
- Give the practical tests and evaluate the tests on the forms provided.
- Reteach and retest as required.
- Complete the appropriate section of the competency profiles.

SUGGESTED RESOURCES

Resources used in developing unit

- Bacon, Miles E. *Automotive Steering, Suspension, and Wheel Alignment.* New York: Gregg Division, McGraw-Hill Book Co., 1988.
- Bacon, Miles E. *Steering, Suspension, and Wheel Service, Unit 1: Inspection of Steering, Suspension, and Wheel Parts,* rev. ed. Tallahassee, Florida: State of Florida Department of Education, 1982.
- *Chilton's Auto Repair Manual, 1985.* Radnor, Pennsylvania: Chilton Book Co., 1984.
- *Chrysler Corporation Technical Guide: Front Suspension, Transmission/Transfer—Power Ram 50.* Centerline, Michigan: Chrysler Corporation Service and Parts Operations, Training Program Development Department, n.d.
- Coghlan, David A. *Automotive Chassis Systems: Steering, Suspension, Alignment, and Brakes,* 2nd ed. Boston: Breton Publishers, A Division of Wadsworth, Inc., 1985.

- Crouse, William H., and Donald L. Anglin. *Automotive Brakes, Suspension, and Steering.* New York: Gregg Division, McGraw-Hill Book Co., 1983.

- Crouse, William H., and Donald L. Anglin. *Automotive Mechanics*, 9th ed. New York: Gregg Division, McGraw-Hill Book Co., 1985.

- deKryger, William J., Robert T. Kovacik, and Saverio G. Bono. *Auto Mechanics: Theory and Service.* Cincinnati, Ohio: South-Western Publishing Co., 1986.

- Duffy, James E. *Modern Automotive Mechanics.* South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1985.

- Ellinger, Herbert E., and Richard B. Hathaway. *Automotive Suspension and Steering: Theory and Service.* Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1989.

- *Moog Front-End Service Manual.* St. Louis, Missouri: Moog Automotive Inc., 1982.

- *1986 Chrysler Engine-Chassis-Body Service Manual: 1986 Front Wheel Drive Passenger Vehicles; Lancer, Daytona, New Yorker, Dodge 600, Aries, Omni, LeBaron GTS, Laser, LeBaron, Caravelle, Reliant, Horizon.* Centerline, Michigan: Chrysler Corp., 1985.

- *Steering, Suspension, and Wheel Service, Unit 2: Adjustment and Replacement of Steering Linkage, Wheel, and Suspension Parts.* Tallahassee, Florida: The Center For Studies in Vocational Education, Florida State University, 1980.

- *Steering, Suspension, Wheel Alignment and Balance: Student Reference Book.* Centerline, Michigan: Chrysler Corp. Service and Parts Operations, Training Program Development Department, n.d.

Media

Spelling and definitions of terminology used in automotive service are not standardized. Media selected to supplement and reinforce material taught in this book may or may not use the same spelling and definitions. Although such deviations should not restrict classroom use of supplemental materials, its existence may confuse some students.

- *Doin' It Right.* 28-minute 16 mm film. Moog Automotive, Inc., c/o Moog Training Center, 6565 Wells Avenue, St. Louis, MO 63133. Discusses typical problems, the need for service, and the relationship of parts to tire wear.
- *Front and Rear Suspension Systems.* 118 slides, 140 page instructor's guide, and a student text. Ford Service Publications, P.O. Box 07150, Detroit, MI 48207, phone 1-800-782-4356.
- *It's Coil Spring Time.* 18-minute 16 mm film. Moog Automotive, Inc., c/o Moog Training Center, 6565 Wells Avenue, St. Louis, MO 63133. Discusses coil spring replacement and use of tools.
- *MacPherson Strut and Rack and Pinion.* Slides, slide carousel, cassette tape, and manual. Moog Automotive, Inc., c/o Moog Training Center, 6565 Wells Avenue, St. Louis, MO 63133. Presents easy-to-follow steps for servicing MacPherson struts and rack and pinion systems.
- *MacPherson Struts.* 22-minute 16 mm film. Moog Automotive, Inc., c/o Moog Training Center, 6565 Wells Avenue, St. Louis, MO 63133. Covers the inspection and replacement of MacPherson strut suspensions on foreign and domestic cars.
- *There's a Need to Know About MacPherson Struts.* 10-minute 16 mm film. TRW, Inc., Replacement Division, 8001 E. Pleasant Valley Road, Cleveland, OH 44131.
- *TRW Technology—The Source for Rack and Pinion.* 16 mm film. TRW, Inc., Replacement Division, 8001 E. Pleasant Valley Road, Cleveland, OH 44131.

- *Twin I-Beam Front Suspension*. Filmstrip, record, and student text. Ford Service Publications, P.O. Box 07150, Detroit, MI 48207, phone 1-800-782-4356.
- *Under Car Inspection Pays Off*. 13-minute 16 mm film. TRW, Inc., Replacement Division, 8001 E. Pleasant Valley Road, Cleveland, OH 44131.

Form 161T 6 80
Supersedes 161T 11 77

WHEEL ALIGNMENT CHECK SHEET

NAME ____________________ MAKE ____________ YEAR ________

ADDRESS ____________________ MODEL ____________ COLOR ________

CITY ____________ STATE ________ ZIP ________ LICENSE ____________________

PHONE ____________ OFFICE PHONE ____________ MILEAGE ____________ DATE ________

PRE-ALIGNMENT INSPECTION

- ☐ NORMAL VEHICLE LOAD
- ☐ TIRE PRESSURES
- ☐ UNEVEN & WORN TIRES
- ☐ WHEEL BEARINGS
- ☐ DRAGGING BRAKES
- ☐ SHOCK ABSORBERS (STRUTS)
- ☐ BALL JOINTS (KING PINS)
- ☐ IDLER ARM
- ☐ STABLIZER
- ☐ TIE RODS & ENDS
- ☐ STEERING ARMS
- ☐ PITMAN ARM
- ☐ SPINDLE
- ☐ BUSHINGS
- ☐ REAR AXLE
- ☐ STEERING WHEEL

LEFT FRONT	CAMBER ANGLE	CASTER ANGLE	TOE
● INITIAL READING			
● FACTORY SPEC			
● FINAL SETTING			

RIGHT FRONT	CAMBER ANGLE	CASTER ANGLE	TOE
● INITIAL READING			
● FACTORY SPEC			
● FINAL SETTING			

TOTAL TOE (FINAL SETTING) ________

REAR	REAR TOE		REAR CAMBER	
	LEFT	RIGHT	LEFT	RIGHT
● INITIAL READING				
● FACTORY SPEC				
● FINAL SETTING				
● TOTAL TOE (FINAL SETTING)				

THRUST ANGLE	
LEFT	RIGHT
FINAL	

	STEERING AXIS INCLIN	INCLUDED ANGLE	WHEEL SET BACK
LEFT			
RIGHT			
SPEC			

TURNING ANGLE		
R	IN	
	OUT	
L	IN	
	OUT	

● CHECK ALL WHEELS & TIRES . . .

CONDITION	LF	RF	LR	RR
PRESSURE				
RUN OUT				
OUT OF ROUND				
EXCESSIVE WEAR				
BALANCE				

● TORISON BAR VEHICLES ONLY . . .

	SUSPENSION HEIGHT	
INITIAL READINGS		
FACTORY SPECS		
FINAL SETTINGS		

● TRUCKS ONLY . . .

FRAME ANGLE	

SUSPENSION HEIGHT	
LEFT	RIGHT

REMARKS ________________________________

____

____

____

____

HUNTER

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SERVICE FRONT SUSPENSION SYSTEMS

EVALUATOR NOTE

Use the following answer key to check student answers to pretest questions. To determine the students' individual study requirements from the pretest results, use the following table which shows the correlation between the objectives and the pretest questions. Then counsel the students individually on pretest results and study requirements.

TABLE

Correlations between objectives and pretest questions:

Objective	Question
1	1, 8, 35, 52, 72
2	2, 9
3	3, 36
4	4, 37, 53
5	5, 6, 7, 26, 27, 28
6	10, 11, 12, 13
7	38, 39, 40, 41
8	55, 56, 57, 58, 59, 67, 68, 69, 70, 71
9	14, 42, 43, 54, 73
10	15
11	16, 17, 18, 19
12	44, 60, 74
13	51, 61
14	20, 29, 45
15A	21, 30, 46, 62, 75
15B	22, 31, 47, 63
15C	23, 32, 48, 64
15D	24, 33, 49, 65
15E	25, 34, 50, 66
15F	38, 39, 40, 41

ANSWER KEY

1. B
2. B
3. C
4. D
5. D
6. B
7. A
8. A
9. C
10. D
11. A
12. C
13. B
14. B
15. A
16. C
17. D
18. D
19. A
20. C
21. D
22. C
23. D
24. A
25. D
26. D
27. C
28. A
29. A
30. A
31. D
32. B
33. C
34. A
35. C
36. A
37. C
38. A
39. B
40. A
41. A
42. A
43. C
44. D
45. B
46. C
47. B
48. A
49. D
50. C
51. C
52. B
53. B
54. B
55. D
56. C
57. A
58. D
59. B
60. C
61. B
62. A
63. D
64. D
65. D
66. B
67. D
68. B
69. D
70. C
71. C
72. A
73. D
74. B
75. C

PRETEST

SERVICE FRONT SUSPENSION SYSTEMS

III

NAME ______________________________ SCORE ________

DIRECTIONS

Read the following questions and problems. Select the item that best answers the question or solves the problem and write the correct letter in the blank.

______1. Which of the following statements best defines *independent suspension*?

A. System in which both wheels attach to the same straight axle; movement of one wheel affects the other wheel
B. System that allows the suspension components on one side of the vehicle to move independently of the other side; movement of one wheel does not affect the other wheel
C. System having separate front and rear third members
D. System that connects the wheels and the vehicle body, absorbs road shock, and provides directional control

______2. Which of the following statements is **not** a purpose of a front suspension system?

A. To work with the steering system to help keep the wheels in correct alignment
B. To allow rapid acceleration with limited body dive
C. To provide a smooth, comfortable ride by allowing the tire and wheel assemblies to move up and down with minimum movement of the car body
D. To support the weight of the front part of the vehicle

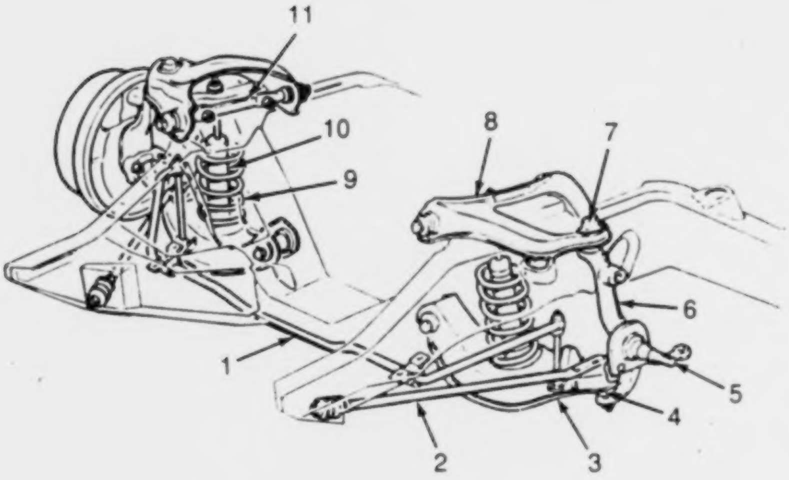
______3. Which of the following is a type of spring used in front suspension systems?

A. Twin I-beam
B. Strut rod
C. Torsion bar
D. All of the above

______4. Which of the following best describes *torsion bar suspension*?

A. Nonindependent suspension system having steel bars that are mounted between the frame and the axle
B. Independent suspension system with front wheels connected to different I-beams
C. Independent suspension system having upper control arms and coil springs which force the steel bars to twist
D. Independent suspension system with metal bars which twist to provide spring action

For items 5-7, refer to the illustration below:



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______5. The part labeled 11 is the:

A. Upper control arm
B. Shock absorber shaft
C. Upper ball joint
D. Upper control arm shaft

______6. The part labeled 7 is the:

A. Steering knuckle
B. Upper ball joint
C. Control arm frame connection
D. Upper control arm shaft

______7. Which part is the stabilizer bar?

A. Part 1
B. Part 2
C. Part 10
D. Part 11

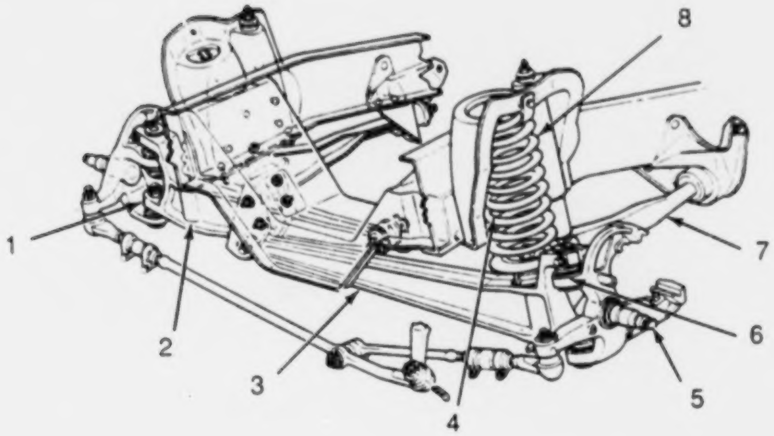
______8. The best definition for *sprung weight* is:

A. Weight of the parts supported by the suspension system
B. Measure of a spring's stiffness or tension
C. Weight of the tire and wheel assembly
D. Weight of the parts that are **not** supported by the suspension system

______9. Technician A says one purpose of the front suspension system is to work with the steering system to help keep the wheels in correct alignment. Technician B says the front suspension system should keep the tires in firm contact with the road. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

For items 10-13, refer to the illustration below:



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_____10. Which part is the radius arm?

A. Part 1
B. Part 2
C. Part 4
D. Part 7

_____11. Which part is the shock absorber?

A. Part 8
B. Part 7
C. Part 2
D. Part 1

_____12. The part labeled 5 is the:

A. I-beam
B. Kingpin
C. Wheel spindle
D. Radius arm

_____13. The part labeled 6 is the:

A. Lower ball joint
B. Upper ball joint
C. Sway bar
D. Insulator

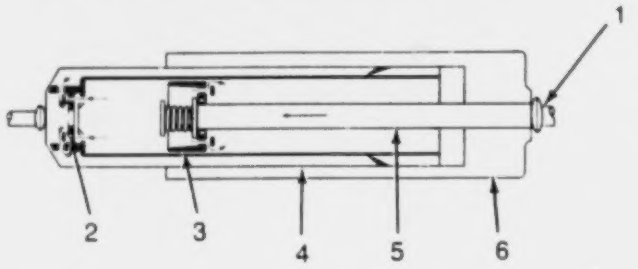
_____14. The purpose of the strut rod is to:

A. Twist to support vehicle weight and absorb shock
B. Keep the lower control arm from moving toward the rear or the front of the vehicle
C. Connect the lower control arm to the steering knuckle
D. Prevent the car body from leaning excessively in sharp turns

_____15. Which of the following statements about ball joints is correct?

A. A load-carrying ball joint supports a portion of vehicle's weight and transmits load from the control arm to the steering knuckle
B. A non-load-carrying ball joint supports a portion of the vehicle's weight and transmits the load from the control arm to the steering knuckle
C. A load-carrying ball joint stabilizes the steering knuckle position during movement of the control arm
D. A non-load-carrying ball joint is never used in a front suspension system

For items 16-19, refer to the illustration below:



Courtesy of Volvo.

_____16. Which part is the reservoir cylinder?

A. Part 1
B. Part 6
C. Part 4
D. Part 3

_____17. The part labeled 2 is the:

A. Upper attachment
B. Fluid reservoir
C. Piston rod
D. Valve

_____18. The part labeled 6 is the:

A. Rod seal
B. Insulator
C. Valve assembly
D. Dust cover

_____19. The part labeled 1 is the:

A. Upper attachment
B. Fluid reservoir
C. Bushing
D. Compression cylinder

_____20. Technicians A and B are discussing front suspension problems. Technician A says a vehicle may lean to one side when cornering if the stabilizer bar is loose. Technician B says a broken spring can usually cause the vehicle to be lower on one side. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______21. Technicians A and B are discussing ball joints in a short-and-long-arm suspension system. Technician A says if the coil spring is on the upper control arm, the lower ball joint is the load-carrying ball joint. Technician B says if the coil spring is on the lower control arm, the lower ball joint is the follower ball joint. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______22. Technicians A and B are discussing coil springs. Technician A says coil springs should be replaced as a set. Technician B says coil springs for the left and right front are usually **not** interchangeable. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______23. Technicians A and B are discussing torsion bar replacement. Technician A says if one bar must be replaced, both bars must be replaced. Technician B says replacement torsion bars come in pairs, and either bar can be used on either side of the vehicle. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

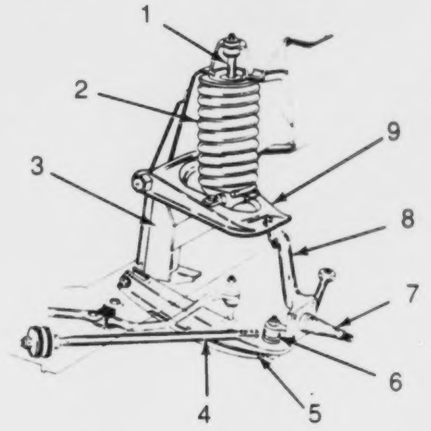
______24. A stabilizer bar is connected to:

A. Both the lower control arms and the vehicle frame
B. Both the upper control arms and the vehicle frame
C. The stabilizer link assembly and the lower control arms
D. The stabilizer link assembly and the upper control arms

_____25. Which of the following statements about MacPherson struts is **not** correct?

A. The bottom of the strut assembly may be connected to the lower control arm
B. The top of the strut assembly is connected to the fender well
C. The bottom of the strut assembly may be connected to the steering knuckle
D. The top of the strut assembly is connected to a frame crossmember

For items 26-28, refer to the illustration below:



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_____26. The part labeled 9 is the:

A. Lower control arm
B. Frame crossmember
C. Steering knuckle
D. Upper control arm

_____27. The part labeled 4 is the:

- A. Stabilizer bar
- B. Tie rod
- C. Strut rod
- D. Torsion bar

_____28. The part labeled 5 is the:

- A. Lower control arm
- B. Spindle assembly
- C. Steering knuckle
- D. Tie-rod end connection

_____29. Technicians A and B are discussing worn shock absorbers. Technician A says worn shocks can cause excessive wheel tramp. Technician B says if a shock is worn, the coil spring must also be worn. Who is correct?

- A. Technician A
- B. Technician B
- C. Both A and B
- D. Neither A nor B

_____30. Which of the following statements about short-and-long-arm suspension systems is **not** true?

- A. The lower control arm is shorter than the upper control arm
- B. The lower control arm may attach to the frame at either one or two points
- C. The upper control arm attaches to the frame with bushings used at the connection
- D. The upper or the lower ball joint may be the load-carrying ball joint

_____31. Technician A says ball joints are unloaded if there is no load in the vehicle's trunk or passenger compartment. Technician B says ball joints are unloaded if the front of the vehicle is raised. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____32. Which of the following statements about torsion bars is **not** correct?

A. An initial twist is placed on the torsion bars by the weight of the vehicle
B. Bent torsion bars can be repaired by heating them and bending them back to their original shape
C. Transverse torsion bars are designed specifically for either the right or left side of the vehicle
D. Rubber bushings are used with transverse torsion bars

_____33. Which of the following statements about stabilizer bars is **not** correct?

A. They are sometimes called a sway bars
B. They are connected to the vehicle frame with brackets
C. They are spring steel bars that connect the left and right upper control arms
D. They are sometimes connected to the lower control arm with a link assembly

_____34. Technicians A and B are discussing MacPherson strut type suspension systems. Technician A says coil springs are used in this type of system. Technician B says coil springs are **not** used in some of the suspension systems having modified MacPherson struts. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____35. *Upward movement of the wheel* best defines which of the following terms?

A. Spring rate
B. Rebound
C. Jounce
D. Extension

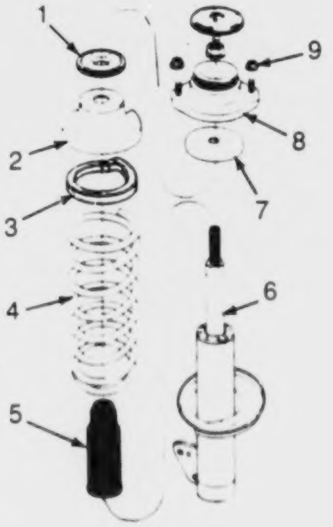
_____36. Technicians A and B are discussing springs used in front suspension systems. Technician A says the types of springs used in front suspension systems are coil, leaf, and torsion bar. Technician B says the types are strut, shock absorber, and coil. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____37. Which of the following best describes *short-and-long-arm coil spring suspension*?

A. Nonindependent suspension system with two sets of control arms with a coil spring on either the upper or the lower arm; may have a strut rod
B. Independent suspension system with two sets of control arms with a strut assembly on each control arm; may have a strut rod
C. Independent suspension system with two sets of control arms and coil springs above or below the upper control arms; may have a strut rod
D. Independent suspension system two sets of control arms with coil springs attached to the steering knuckles; also has a strut rod

For items 38-41, refer to the illustration below:



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______38. Which part is the upper mount?

A. Part 8
B. Part 4
C. Part 1
D. Part 5

______39. Which part is the spring seat?

A. Part 8
B. Part 2
C. Part 10
D. Part 11

_____40. The part labeled 3 is the:

- A. Spring insulator
- B. Dust cap
- C. Upper mount
- D. Shock absorber

_____41. The part labeled 4 is the:

- A. Coil spring
- B. Upper control arm
- C. Steering knuckle
- D. Dust cap

_____42. The purpose of a stabilizer bar is to:

- A. Prevent the car body from leaning excessively in sharp turns
- B. Keep the lower control arms from swinging toward the rear or the front of the car
- C. Connect the control arms to the frame
- D. Both A and C

_____43. Which part of the front suspension system connects the frame or the body to the steering knuckle?

- A. Tie-rod
- B. Spindle
- C. Control arm
- D. None of the above

_____44. Which of the following statements about shock absorbers is correct?

- A. Gas-charged shock absorbers are used when the ride quality may need to be changed
- B. Load-leveling type shock absorbers are used on vehicles that commonly carry heavy loads
- C. Adjustable shocks are used primarily when a firmer ride is desired
- D. All of the above

_____45. Technicians A and B are discussing a vehicle with uneven curb height. Technician A says the strut rod must be damaged. Technician B says the coil springs could be sagging. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____46. Technician A says when checking for wear at the control arm ball joints, the readings should be compared to manufacturer's specifications. Technician B says on some vehicles only up and down movement is checked. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____47. Which of the following statements is **not** correct?

A. On some vehicles, the tie-rod end must be disconnected in order to recondition a short-and-long-arm suspension
B. On some vehicles, the tie-rod end must **not** be disconnected when reconditioning a short-and-long-arm suspension
C. On all vehicles, the spindle assembly must be disconnected when replacing the control arms
D. On all vehicles, the ball joints must be disconnected when replacing the spindle assembly

_____48. A steering and suspension technician has replaced and adjusted a vehicle's torsion bars. What should the technician do next?

A. Measure the vehicle height, adjust again if necessary, remeasure, then check the wheel alignment
B. Nothing; the vehicle is ready to return to the customer
C. Measure torsion bar height, adjust again if necessary, and remeasure
D. Replace the coil springs and remeasure vehicle height

_____49. When replacing the stabilizer bar and its related parts, which of the following statements is correct?

A. Disconnect the upper control arm mounting brackets before disassembling the stabilizer bar link assembly
B. Disconnect the upper control arm before disassembling the stabilizer bar mounting bracket assembly
C. Assemble the stabilizer bar link assembly before connecting the stabilizer bar
D. Disassemble the stabilizer bar link assembly, disconnecting the bar before disconnecting the stabilizer bar mounting brackets

_____50. Which of the following statements about MacPherson strut service is **not** correct?

A. Both front struts should be replaced, even if only one needs to be replaced
B. Some struts can be repaired; others must be replaced
C. The mounting fastener and the top strut assembly fastener must be removed when taking the strut off the vehicle
D. The position of the cam bolt should be marked before disconnecting the strut assembly from the steering knuckle

______51. Which of the following best describes a manual leveling suspension system?

A. Sensor-activated system that uses air shocks, height or level sensors, and an electric compressor to maintain the curb height as passenger and luggage weights change
B. Operator-controlled and sensor-activated system that is vacuum-operated to maintain the curb weight as the passenger weight changes
C. Operator-controlled, vacuum-operated or electric compressor-operated system that uses air shocks to change the vehicle height as passenger and luggage weights change
D. Operator-controlled system that uses air shocks, height or level sensors, and an electric compressor to maintain the curb height as passenger and luggage weights change

______52. *Wheel downward movement from its normal position* best defines which of the following terms?

A. Spring rate
B. Rebound
C. Jounce
D. Compression

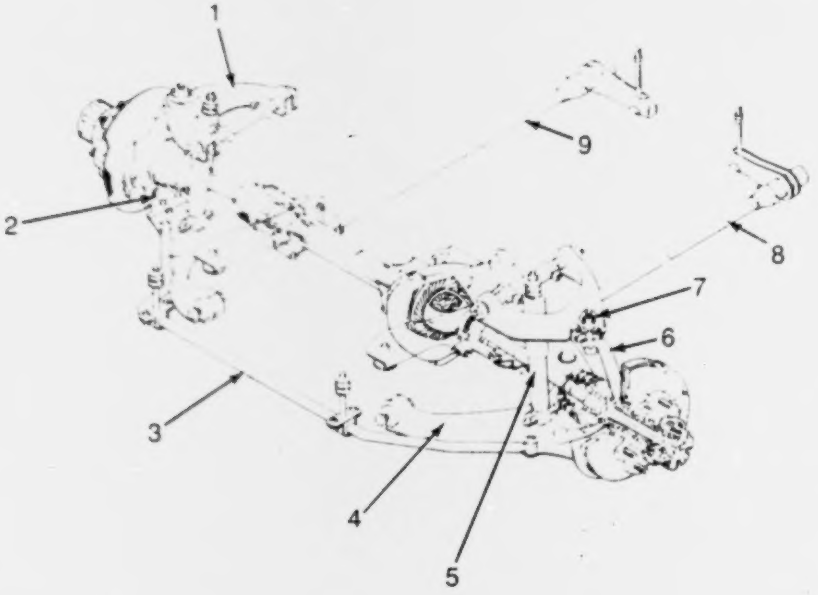
______53. Which of the following best describes *MacPherson strut suspension*?

A. Independent suspension system with lower and upper control arms and a strut assembly which includes a coil spring and a strut shock
B. Independent suspension system with a lower control arm and strut assembly which includes a coil spring and a shock absorber
C. Nonindependent suspension system having an upper control arm, strut assembly, and coil spring mounted on the control arm
D. None of the above

_____54. Which part of a front suspension system twists to support body weight and absorb shock?

A. Shock absorber
B. Torsion bar
C. Coil spring
D. Strut rod

For items 55-59, refer to the illustration below:



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_____55. The part labeled 3 is the:

A. Front torsion bar
B. Left torsion bar
C. Right torsion bar
D. Stabilizer bar

_____56. The part labeled 9 is the:

A. Frame crossmember
B. Lower control arm
C. Right torsion bar
D. Stabilizer bar

_____57. The part labeled 4 is the:

A. Lower control arm
B. Steering knuckle
C. Torsion bar anchor assembly
D. Upper control arm

_____58. The part labeled 5 is the:

A. Stabilizer bar
B. Rear ball joint
C. Lower control arm
D. Shock absorber

_____59. Which part is the upper control arm?

A. Part 6
B. Part 1
C. Part 4
D. None of the above

_____60. When is an air shock usually used?

A. Used primarily when a firmer ride is desired
B. Used when the ride quality may need to be changed
C. Used when loads and ride heights vary; used as part of a leveling suspension system
D. Used on vehicles that commonly carry lighter loads

_____61. Which of the following best describes an automatic leveling suspension system?

A. Operator-controlled, vacuum-operated or electric-compressor-operated system that uses air shocks to change the vehicle height as passenger and luggage weights change
B. Sensor-activated system that uses air shocks, height or level sensors, and an electric compressor to maintain the curb height as passenger and luggage weights change
C. Sensor-activated, vacuum-operated system that uses coil springs and air shocks to change the vehicle height as luggage weight changes
D. Operator-controlled system that uses level sensors to adjust the vehicle height as passenger and luggage weights change

_____62. Which of the following statements about inspecting short-and-long-arm suspension system components is correct?

A. Make sure the wheel bearings are properly adjusted before inspection
B. The vehicle must be on an alignment rack with stops in place
C. Measure the radial play using a radial micrometer
D. None of the above

_____63. Which of the following statements about control arm ball joints is correct?

A. They may be riveted to the control arm
B. They may be bolted to the control arm
C. They may be pressed into the control arm
D. All of the above

_____64. Which of the following statements about torsion bar adjustment is correct?

A. Both sides must be replaced and adjusted
B. Both sides must be measured, but it may be necessary to adjust only one torsion bar
C. Adjusting one torsion bar will affect the height of the other side of the vehicle
D. Both B and C

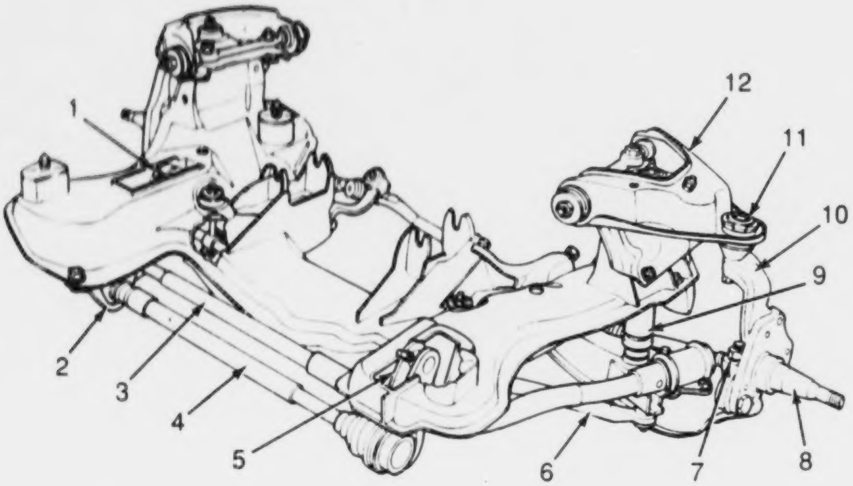
_____65. When mounting the stabilizer bar on the frame:

A. Install mounting bracket bolts and finger-tighten
B. Do **not** torque mounting bracket bolts until the vehicle has been lowered to the floor
C. Make sure the flat side of the bushings face the frame and the brackets are properly positioned on the bushings
D. All of the above

_____66. Technician A says he performed a bounce test to check the strut operation on a vehicle in the shop. Since the test showed the struts appeared to be in good condition, he says repair or replacement is **not** necessary. Technician B says the struts should also be inspected for leakage and the bearings should be checked. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

For items 67-71, refer to the illustration below.



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_____67. The part labeled 3 is the:

A. Stabilizer bar
B. Strut rod
C. Left control arm
D. Left torsion bar

_____68. The part labeled 11 is the:

A. Stabilizer bar
B. Upper ball joint
C. Left torsion bar
D. None of the above

_____69. Which part is the shock absorber?

A. Part 7
B. Part 10
C. Part 1
D. Part 9

_____70. Which part is the left torsion bar anchor?

A. Part 7
B. Part 11
C. Part 1
D. Part 2

_____71. The part labeled 2 is the:

A. Left torsion bar anchor
B. Right torsion bar anchor
C. Pivot bushing
D. None of the above

_____72. *Independent suspension system with two sets of control arms and coil springs above or below the upper control arms (may have a strut rod)* best defines which of the following terms?

A. Short-and-long-arm suspension
B. Control arm strut suspension
C. Torsion bar coil spring suspension
D. None of the above

_____73. The front suspension parts that allow the control arm to move up and down are the:

A. Ball joints
B. Coil springs
C. Anchor assemblies
D. Control arm bushings

_____74. Which of the following are uses of an *adjustable shock absorber*

A. Is never used
B. Used when the ride quality may need to be changed
C. Used when the loads and ride heights vary; used as part of a leveling suspension system
D. Used on vehicles that commonly carry heavy loads

_____75. Technicians A and B are discussing control arm ball joints. Technician A says if the wear indicator is flush with or inside the bottom plate, the ball joint is worn and should be replaced. Technician B says a check of the axial and radial movement should be made before deciding to replace a ball joint without a wear indicator. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

INFORMATION SHEET

SERVICE FRONT SUSPENSION SYSTEMS III

OBJECTIVE 1

Select the definitions of terms associated with front suspension system service.

axial — Parallel to the shaft

ball joints — Parts that join the steering and suspension components to allow the necessary pivoting or movement of components

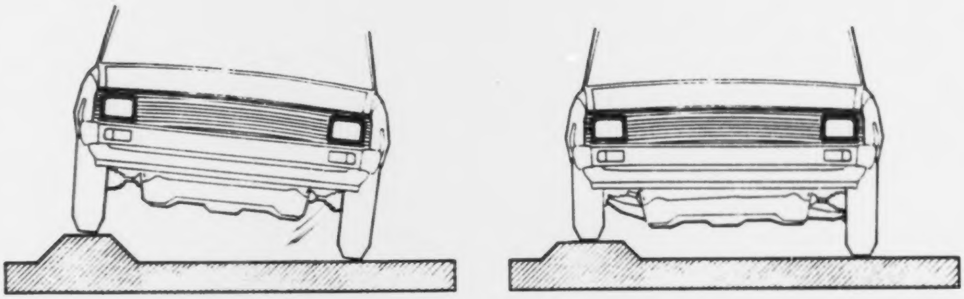
control arm — Suspension component connecting the vehicle frame and the steering knuckle; acts as a hinge to allow up-and-down movement of the tire and wheel assembly

NOTE: This is sometimes referred to as an A-frame.

independent suspension — System that allows the suspension components on one side of the vehicle to move independently of the other side; movement of one wheel does not affect the other wheel (Figure 1)

EXAMPLE:

FIGURE 1



Nonindependent **Independent**

jounce — Upward movement of the wheel

nonindependent (solid-axle) suspension — System in which both wheels attach to the same straight axle; movement of one wheel affects the other wheel (See Figure 1.)

radial — Perpendicular to the shaft

rebound — Wheel downward movement from its normal position

short-and-long-arm suspension (SLA) — System with short upper and longer lower control arms

spring rate — Measure of the weight needed to compress a spring

> **NOTE:** The spring rate increases as the spring is compressed.

sprung weight — Weight of the parts supported by the suspension system

steering knuckle — Suspension component attached to the upper and lower control arms and to the tie-rod ends by ball joints

suspension — Vehicle system that connects the wheels and the vehicle body, carries vehicle load, maintains body height, absorbs road shock, and provides directional control

unsprung weight — Weight of the parts that are *not* supported by the suspension system

> EXAMPLE: The tires, wheels, brake system, wheel bearings, steering knuckles, or axle housing are considered unsprung weight.

vehicle (curb) height — Distance between a flat, level surface and points on the vehicle

> **NOTE:** Vehicle height is measured from points specified by the manufacturer. To keep measurements accurate, the amount of fuel in the tank, air in the tires, and other load variables must be brought to manufacturer's specifications before vehicle height is measured.

OBJECTIVE 2

State the purposes of a front suspension system.

- Supports the weight of the front part of the vehicle

  NOTE: Besides suspending the vehicle's front end, the suspension also provides the support that is needed when the brakes are applied. When a vehicle's brakes are applied, there is a tendency for the front of the vehicle to tilt down. This tilting is called *body dive*.

- Provides a smooth, comfortable ride by allowing the tire and wheel assemblies to move up and down with minimum movement of the car body

- Allows rapid cornering without extreme body roll

  NOTE: The state of the vehicle leaning to one side is called *body roll*.

- Keeps the tires in firm contact with the road

  NOTE: The suspension system allows the tires to maintain road contact when traveling over high and low points of the road surface, such as when striking bumps or holes in the road.

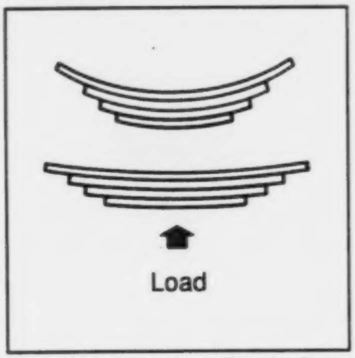
- Works with the steering system to help keep the wheels in correct alignment

OBJECTIVE 3 **List the types of springs used in front suspension systems.**

Leaf springs (Figure 2)

EXAMPLE:

FIGURE 2



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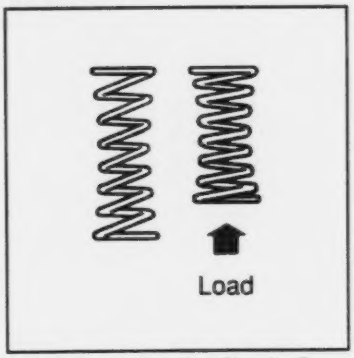
Coil springs (Figure 3)

EXAMPLE:

FIGURE 3



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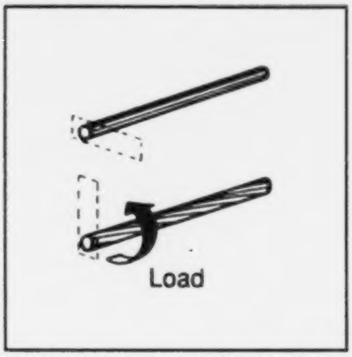
Torsion bar (Figure 4)

EXAMPLE:

FIGURE 4



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OBJECTIVE 4

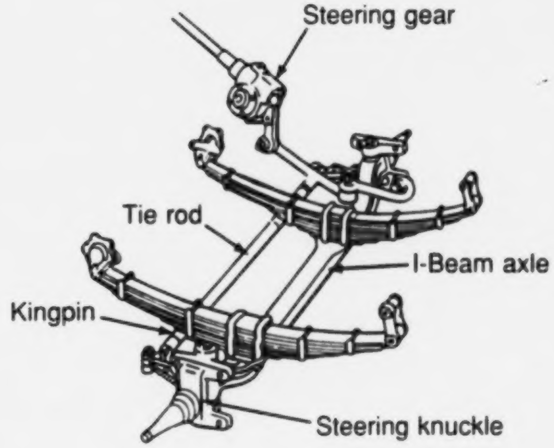
Describe the types of front suspension systems.

Leaf spring suspension — Nonindependent suspension system with leaf springs (Figure 5)

NOTE: Leaf spring suspensions are used on the front suspensions of larger trucks or four-wheel drive trucks.

EXAMPLE:

FIGURE 5


Steering gear
Tie rod
I-Beam axle
Kingpin
Steering knuckle

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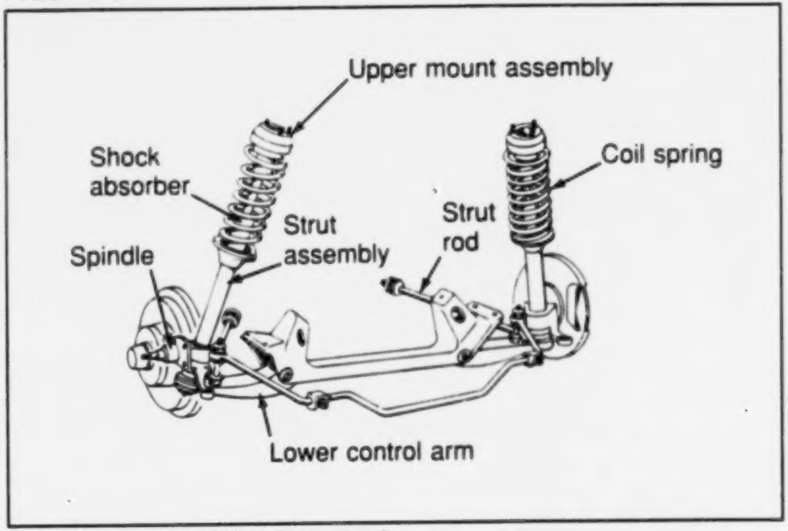
MacPherson strut suspension — Independent suspension system with a lower control arm and strut assembly which includes a coil spring and a shock absorber (Figure 6)

NOTE: There are many modifications of this type of suspension system. One type, called a modified strut, has the coil mounted separately from the strut.

EXAMPLE:

FIGURE 6


Upper mount assembly
Shock absorber
Coil spring
Strut assembly
Strut rod
Spindle
Lower control arm

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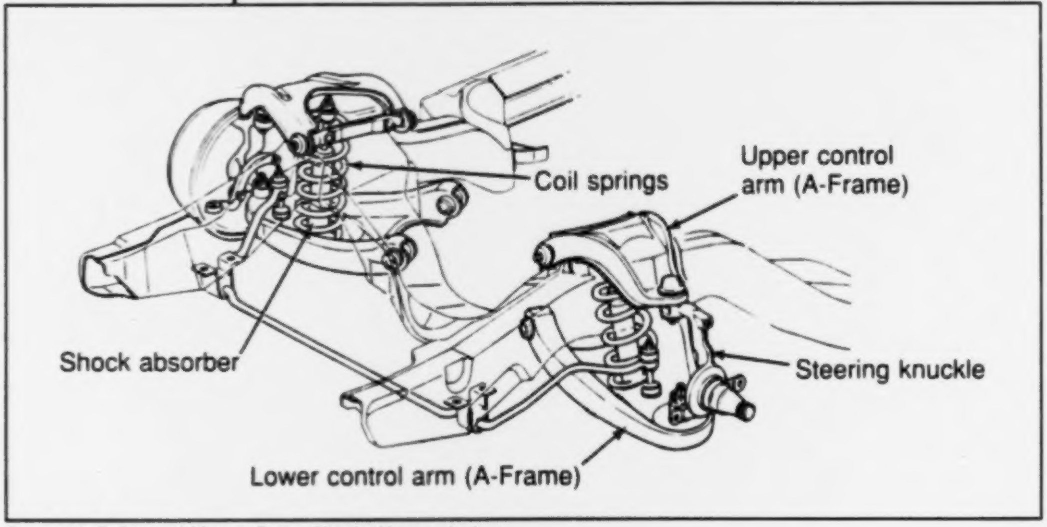
Short-and-long-arm coil spring suspension (SLA) —
Independent suspension system with two sets of control arms and coil springs above or below the upper control arms; may have a strut rod (Figure 7)

NOTE: This system is so named because the upper arm is shorter than the lower arm.

EXAMPLE:

FIGURE 7


Coil springs
Upper control arm (A-Frame)
Shock absorber
Steering knuckle
Lower control arm (A-Frame)

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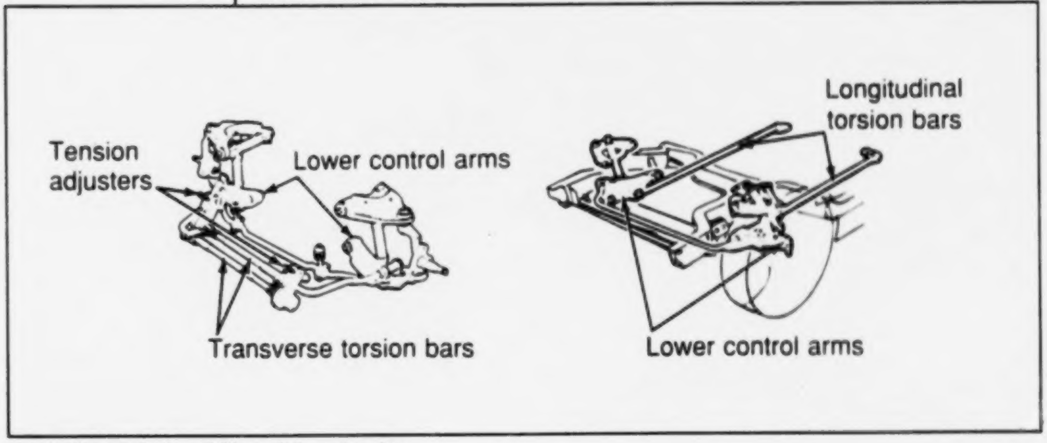
Torsion bar suspension — Independent suspension system having metal bars which twist to provide spring action (Figure 8)

NOTE: Torsion bars that are mounted parallel to the frame are called *longitudinal* torsion bars. Those that are mounted crosswise are called *transverse* torsion bars. Longitudinal torsion bars are more commonly used.

EXAMPLE:

FIGURE 8


Tension adjusters
Lower control arms
Transverse torsion bars
Longitudinal torsion bars
Lower control arms

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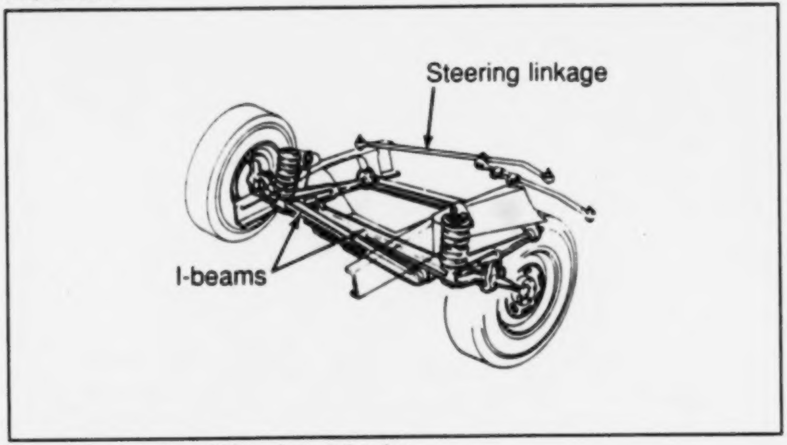
Twin I-beam suspension — Independent suspension system with the front wheels connected to different I-beams and a coil spring mounted between each I-beam and the frame (Figure 9)

NOTE: This type of suspension is used more often on pickups or light-duty trucks than on passenger cars.

EXAMPLE:

FIGURE 9



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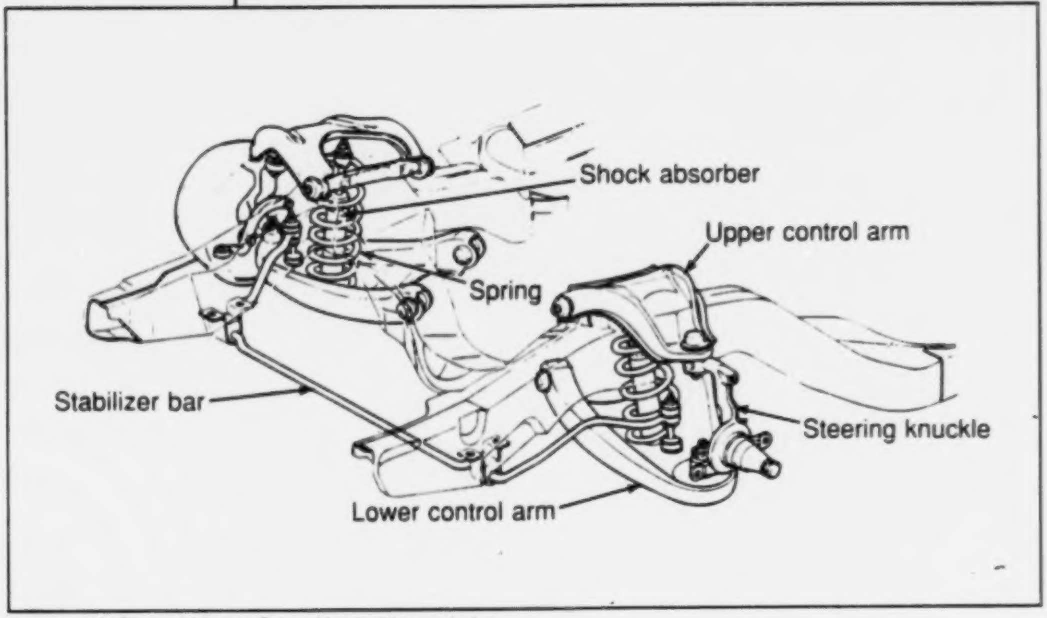
OBJECTIVE 5 **Label the parts of a short-and-long-arm suspension system.**

FIGURE 10


Shock absorber
Upper control arm
Spring
Stabilizer bar
Steering knuckle
Lower control arm

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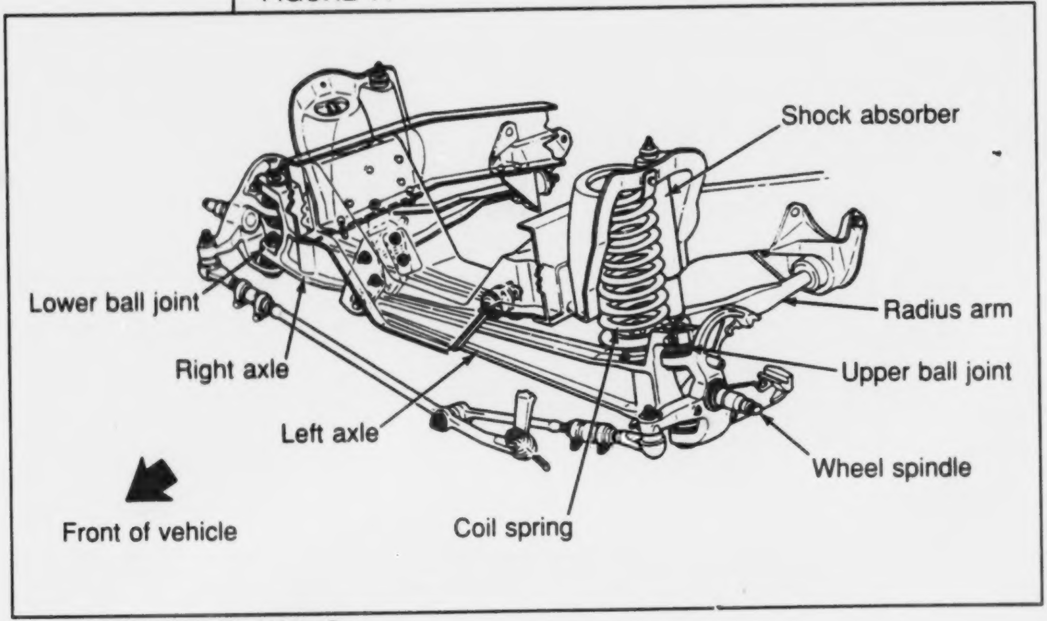
OBJECTIVE 6 **Label the parts of a twin I-beam suspension system.**

FIGURE 11


Shock absorber
Lower ball joint
Radius arm
Right axle
Upper ball joint
Left axle
Wheel spindle
Front of vehicle
Coil spring

Used with permission of Ford Motor Co.

NOTE: Some I-beams have kingpins.

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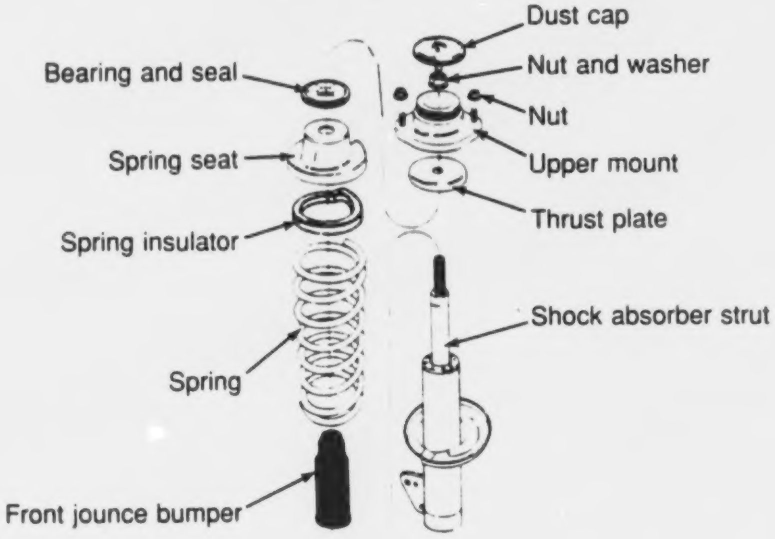
OBJECTIVE 7 **Label the parts of a MacPherson strut suspension system.**

FIGURE 12


Dust cap
Bearing and seal
Nut and washer
Nut
Spring seat
Upper mount
Thrust plate
Spring insulator
Shock absorber strut
Spring
Front jounce bumper

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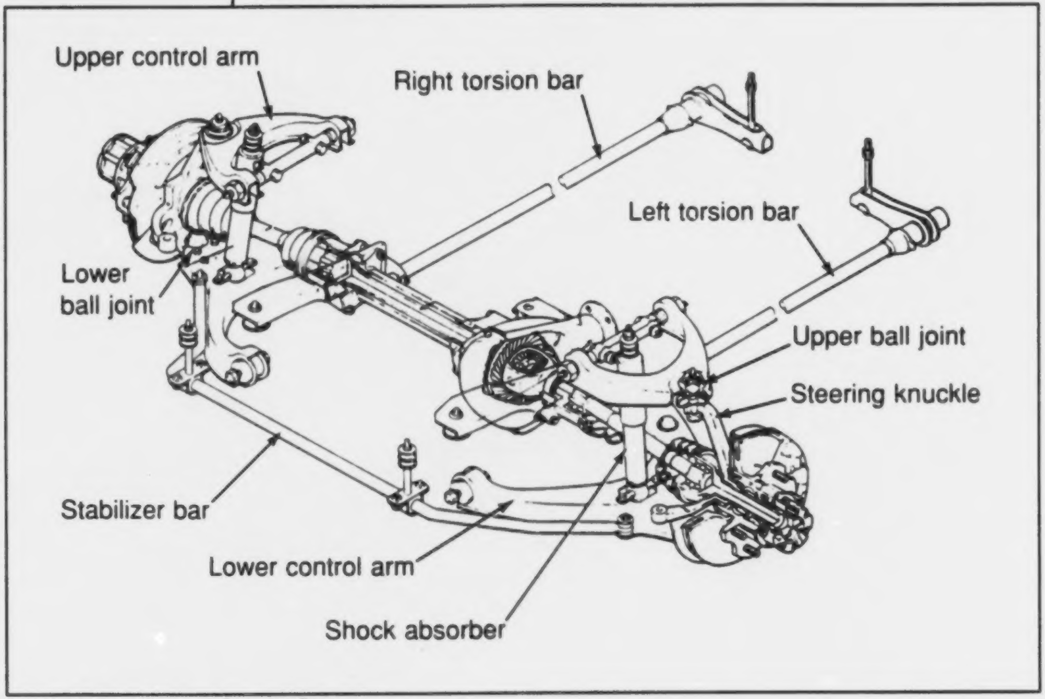
More About Strut Suspensions

More and more cars are equipped with strut suspension systems. There are many features about this type of suspension system which make it desirable. Because it has fewer points of attachment to the vehicle, the front end does not require alignment as often. Most strut suspensions do not have the upper control arms and ball joints found on more conventional suspension systems. This lightens the weight of the suspension and improves gasoline mileage. Additionally, strut suspensions take up less room in the engine compartment, allowing more space for the transverse mounted engines used in most front-wheel drive cars.

OBJECTIVE 8 **Label the parts of torsion bar suspension systems.**

Longitudinal (Figure 13)

FIGURE 13


Upper control arm
Right torsion bar
Left torsion bar
Lower ball joint
Upper ball joint
Steering knuckle
Stabilizer bar
Lower control arm
Shock absorber

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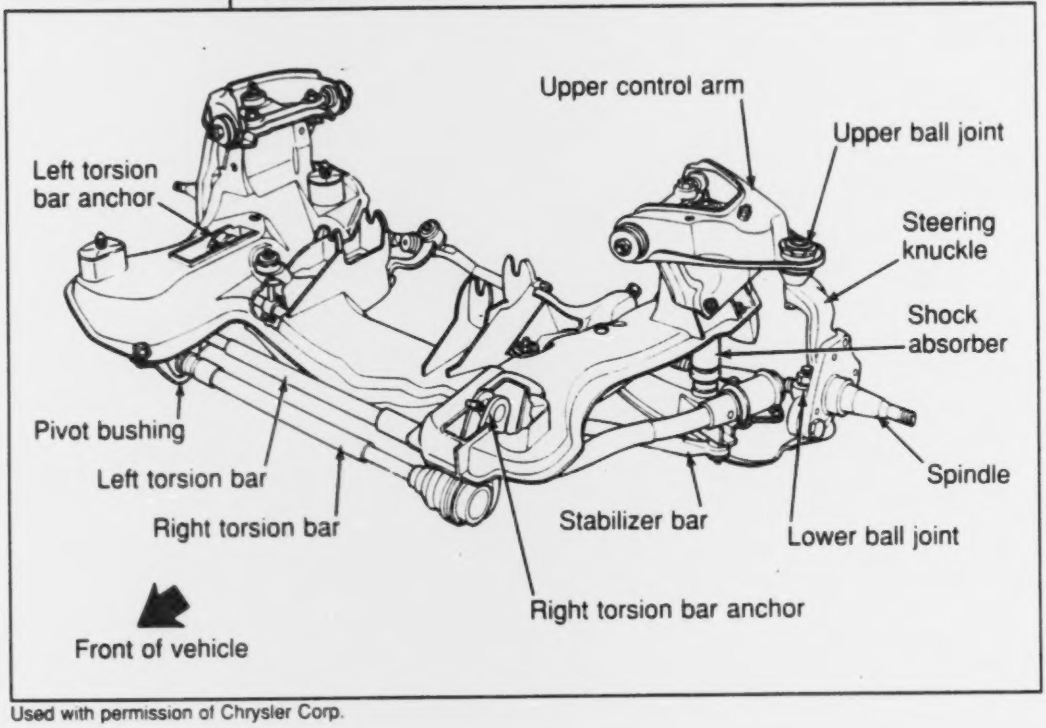
TORSION BARS

In a torsion bar suspension system, torsion bars support the vehicle weight and absorb road shock. While coil springs perform these functions by compressing, torsion bars act by twisting. Torsion bars are connected either longitudinally or transversely between the lower control arms and the frame.

The components of this system are basically the same as those in the short-and-long-arm coil spring suspension. The shock absorbers dampen the twisting motion of the torsion bars.

Transverse (Figure 14)

FIGURE 14


Upper control arm
Upper ball joint
Left torsion bar anchor
Steering knuckle
Shock absorber
Pivot bushing
Left torsion bar
Spindle
Right torsion bar
Stabilizer bar
Lower ball joint
Right torsion bar anchor
Front of vehicle

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OBJECTIVE 9 **Match front suspension system parts to their purposes.**

Ball joint — Connects the steering knuckle to the control arm and provides swivel points (See Figure 14.)

NOTE: Ball joints can be pressed, bolted, riveted, or screwed into the control arm.

Coil spring — Supports vehicle load

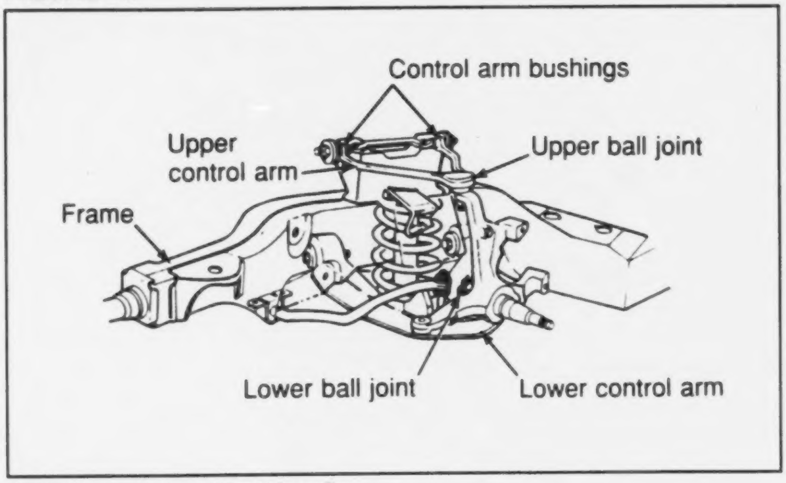
NOTE: The control arms allow the coil springs to expand and compress as road conditions affect the wheels.

Control arm — Connects the body or frame to the steering knuckle

Control arm bushing — Allows the control arm to move up and down (Figure 15)

EXAMPLE:

FIGURE 15


Control arm bushings
Upper control arm
Upper ball joint
Frame
Lower ball joint
Lower control arm

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Shock absorber — Dampens the rebound and compression action of the coil spring to keep the tire on the road surface

NOTE: It there was no shock absorber, the wheel would be pulled upward away from the road surface every time the spring rebounded.

Spindle — Mounting shaft for the wheel and hub

Stabilizer bar (sway bar) — Prevents the car body from leaning excessively in sharp turns

NOTE: The stabilizer bar is connected to the control arms and the frame. Rubber bushings fit between the bar, control arms, and frame.

Steering knuckle — Provides wheel connection to the suspension and to the tie-rod ends for steering; provides a place to mount the wheel so the wheel can pivot

NOTE: The steering knuckle is sometimes called the *spindle*, because the spindle is attached to, or in some instances, is a part of the steering knuckle.

Strut rod — Keeps the lower control arm from moving toward the front or rear of the vehicle

NOTE: A strut rod is used if the lower control arm attaches to the frame at only one point rather than two.

Torsion bar — Twists to support vehicle body weight and absorb shock

NOTE: A torsion bar is attached to a control arm and a frame crossmember. As wheel movement causes the control arm to move up and down, the torsion bar twists.

OBJECTIVE 10 **State the functions of load-carrying and non-load-carrying ball joints.**

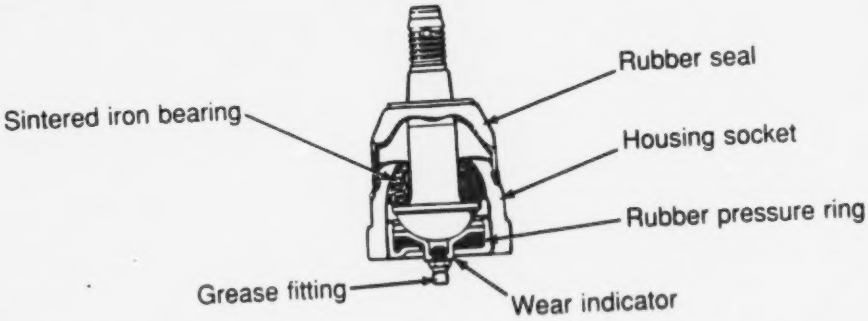
Load-carrying ball joint — Supports a portion of the vehicle's weight; transmits load from the control arm to the steering knuckle

Non-load-carrying ball joint — Stabilizes the steering knuckle position during movement of the control arm

NOTE: A non-load-carrying ball joint is sometimes called a *following* ball joint.

MORE ABOUT BALL JOINTS

A ball joint consists of a ball or half a ball connected to a stud and a socket which houses the ball portion. This type of joint is similar to the ball-and-socket joint in your shoulder or hip. Below is an illustration of a basic ball joint.


Rubber seal
Sintered iron bearing
Housing socket
Rubber pressure ring
Grease fitting
Wear indicator

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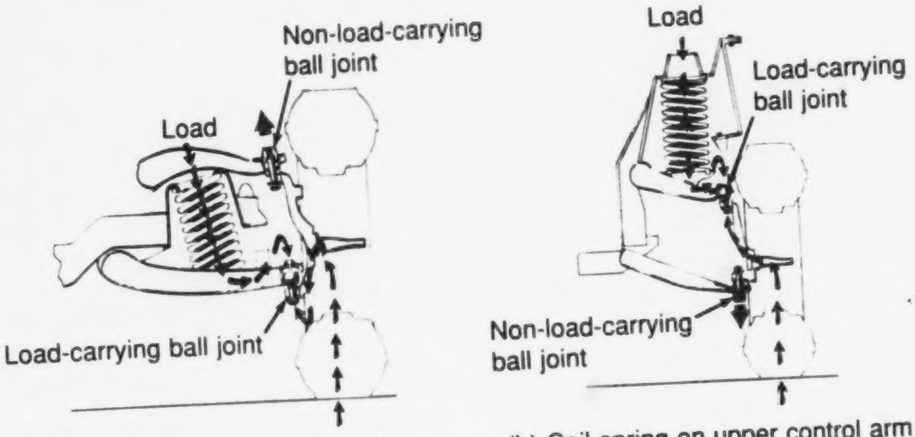
These joints are sealed in order to contain the lubricating grease and to prevent it from becoming contaminated. Some ball joints have a *zerk* fitting, where lubrication can be added.

Whether or not a ball joint is load-carrying or non-load-carrying depends upon the type of suspension system and the location of the coil spring (in long-and-short-arm suspensions).


Non-load-carrying ball joint
Load
Load-carrying ball joint
Load
Load-carrying ball joint
Non-load-carrying ball joint

(a) Coil spring on lower control arm (b) Coil spring on upper control arm

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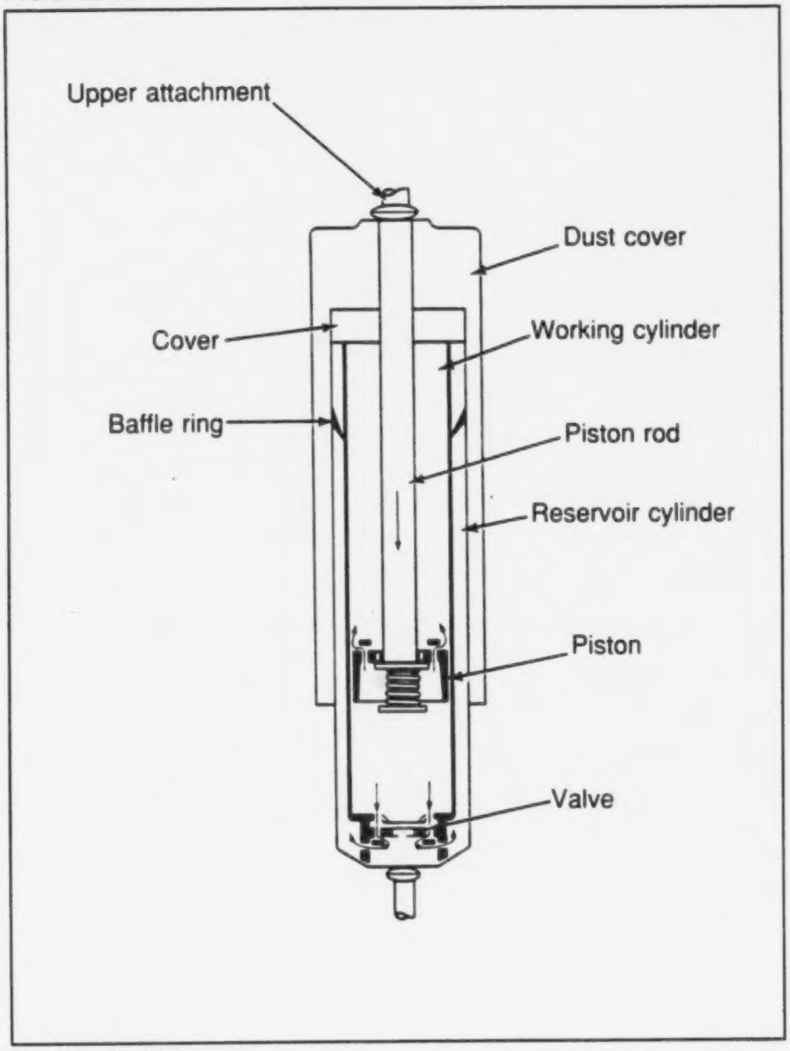
OBJECTIVE 11 **Label the parts of a shock absorber.**

FIGURE 16


Upper attachment
Dust cover
Cover
Working cylinder
Baffle ring
Piston rod
Reservoir cylinder
Piston
Valve

Courtesy of Volvo.

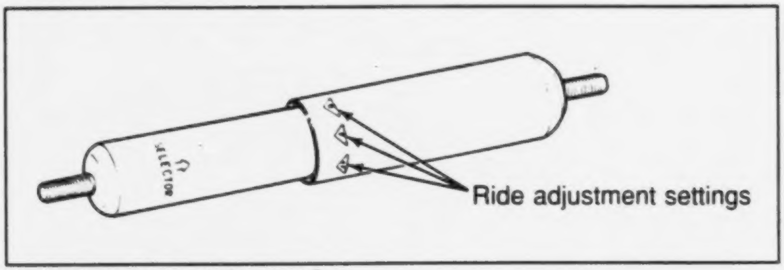
OBJECTIVE 12

Match the types of shock absorbers to their uses.

Adjustable shock absorbers — Used when the ride quality may need to be changed (Figure 17)

EXAMPLE:

FIGURE 17



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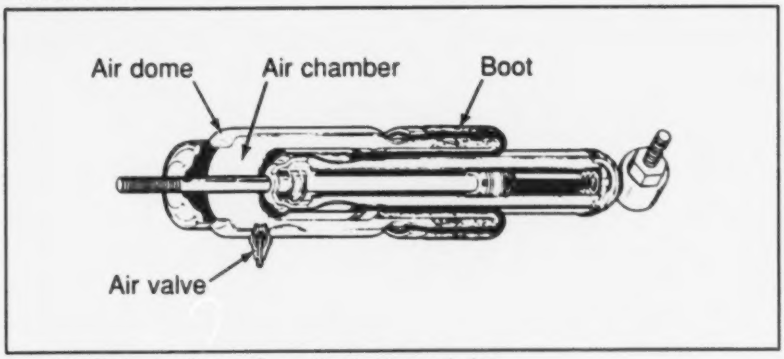
Air shock absorbers — Used when loads and ride heights vary; used as part of leveling suspension systems (Figure 18)

NOTE: Air shock absorbers are adjusted either manually or automatically by adding air to the shock or venting air from it. Leveling systems, which are either manual or automatic, use air shock absorbers to adjust vehicle height.

EXAMPLE:

FIGURE 18



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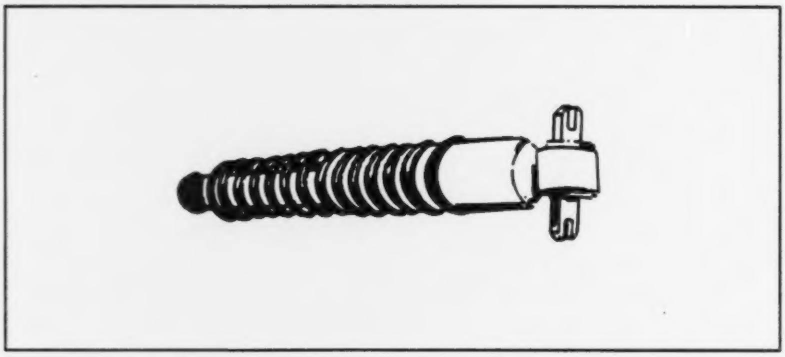
Gas-charged shock absorbers — Used primarily when a firmer ride is desired; the gas is used to control fluid aeration

Load-leveling type shock absorbers — Used on vehicles that commonly carry heavy loads (Figure 19)

NOTE: This is a standard hydraulic shock with a coil spring surrounding it. The spring provides extra support when the vehicle has heavier than normal loads.

EXAMPLE:

FIGURE 19



OBJECTIVE 13 **Describe the types of adjustable leveling suspension systems.**

NOTE: Leveling systems are used on both large and small vehicles. They are more commonly used on luxury vehicles. Adjustable leveling systems can be used on sports cars, allowing the driver to control the stiffness of the ride by selecting ride control options.

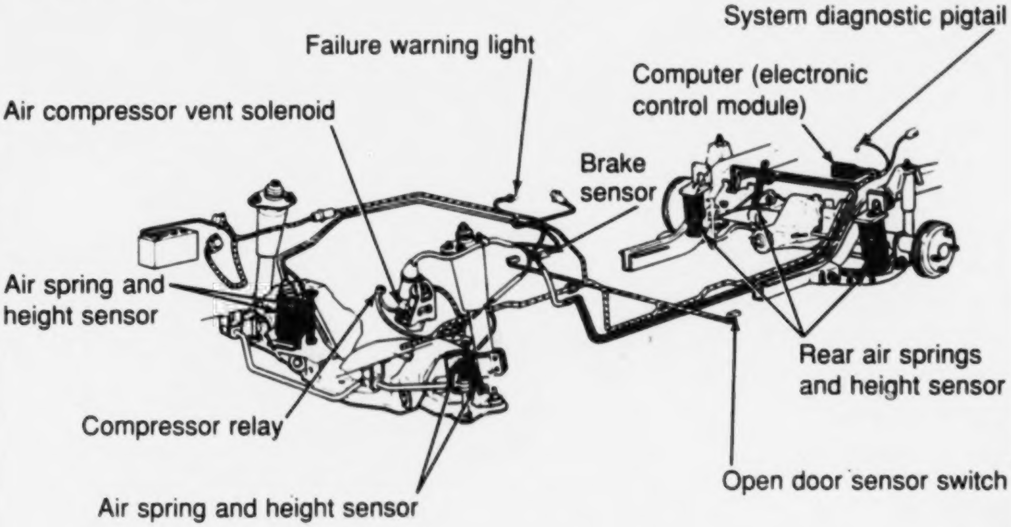
- **Manual** — Operator-controlled, vacuum-operated or electric-compressor-operated system that uses air shocks to change the vehicle height as passenger and luggage weights change

  NOTE: A manual switch activated by the driver causes either the compressor to add air pressure or an exhaust valve to reduce air pressure. This in turn changes vehicle height. Manual leveling systems are used primarily in rear suspension systems.

- **Automatic** — Sensor-activated system that uses air shocks, height or level sensors, and an electric compressor to maintain the curb height as passenger and luggage weights change

LEVELING SYSTEMS

Leveling suspension systems are used to maintain proper vehicle height. When the height is correct, there is adequate clearance for the suspension, and the alignment settings will be near normal. If a vehicle has a heavy load which weighs down either end of the vehicle (or the entire vehicle), suspension parts may not have necessary clearance and may not perform satisfactorily. Also, as excess weight is applied to the vehicle, the alignment angles change, which can affect steering and cause improper tire wear. Most leveling systems primarily adjust the height of the rear of the vehicle to compensate for extra weight in that area.


System diagnostic pigtail
Failure warning light
Computer (electronic control module)
Air compressor vent solenoid
Brake sensor
Air spring and height sensor
Rear air springs and height sensor
Compressor relay
Open door sensor switch
Air spring and height sensor

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Automatic leveling systems are usually unique to the manufacturer and can be tested and repaired using only the tools and equipment especially designed for a particular system. To learn the proper procedures for servicing an automatic leveling system, the steering and suspension technician must attend special vehicle manufacturer's training programs.

TROUBLESHOOTING FRONT SUSPENSION SYSTEM PROBLEMS

All front suspension components must be in good working order and the suspension system itself must perform satisfactorily before alignment can be adjusted. Therefore, it is important that the steering and suspension technician be able to accurately diagnose any front suspension problems and make necessary repairs.

Diagnosis is a complex task and acquiring the necessary skills is usually a result of experience. However, the technician can follow some basic troubleshooting steps. If possible, the technician should test drive the vehicle to verify the customer's complaint and note any other problems. He or she should also refer to the appropriate service manual diagnostic charts and visually inspect all suspension system parts and components.

MacPherson strut type suspensions are very popular. Many diagnostic charts contain information about strut suspension problems. For instance, one problem associated with MacPherson strut systems is memory steer or poor returnability. This can be an indication that the bearings located in the upper strut assembly are either seized or worn. Another indication of worn bearings is a grinding sound.

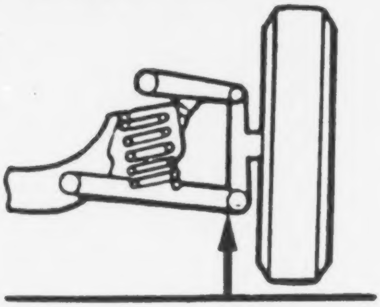
It is important for the service technician to listen carefully to determine the type of sound (such as clunking, squeal, grinding, etc.) to narrow down the possibilities and then make a thorough inspection of the suspension system. On the next page is a table listing different front-end noises and the possible causes of each.

TABLE 1 — **Front-end noise diagnosis**

NOISE	PROBABLE CAUSE
Clunking	• Loose or worn shock mountings • Loose torsion bar • Severely worn control arm bushings* • Severely worn ball joints* *These damaged or worn parts normally would **not** produce noise unless badly worn, so it is important to visually inspect them
Squeak	• Loose or broken coil springs • Control arm bushings, dry ball joints
Grinding	• Worn or damaged bearings in MacPherson strut assembly

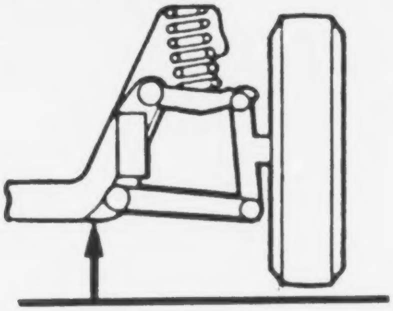
Jack-Stand Placement For Checking Ball Joints

Coil spring on lower control arm



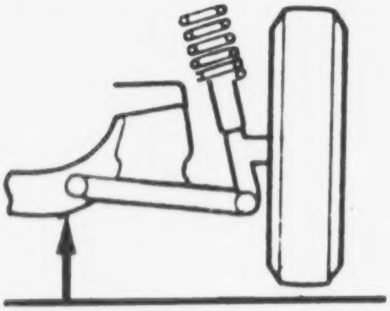
Place jack stand under control arm.

Coil spring on upper control arm



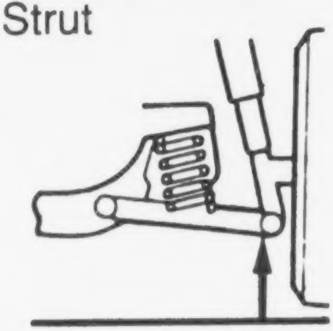
Place jack stand under frame.

MacPherson Strut



Place jack stand under frame.

Modified MacPherson Strut



Place jack stand under control arm.

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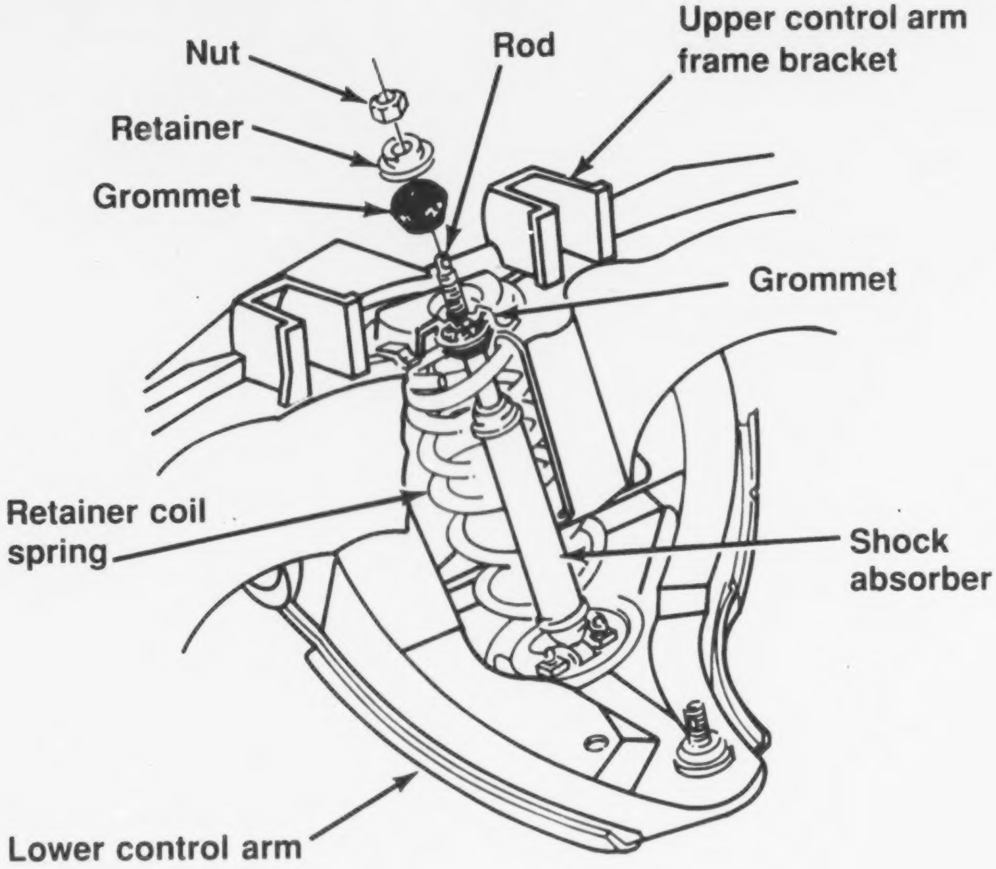
Shock Absorber Installation


Nut
Retainer
Grommet
Rod
Upper control arm frame bracket
Grommet
Retainer coil spring
Shock absorber
Lower control arm

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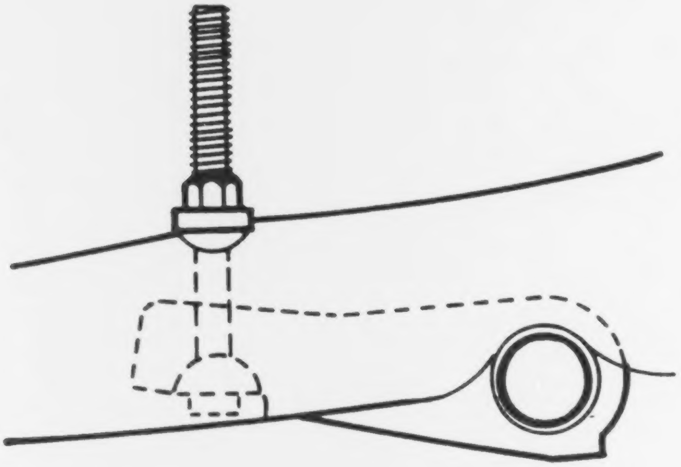
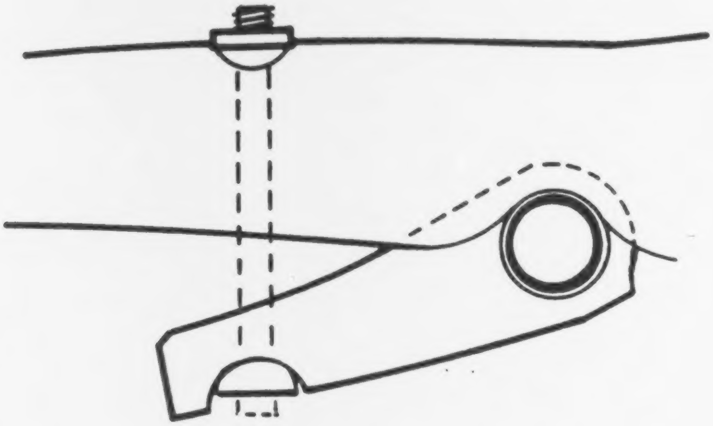
Torsion Bar Adjustment



Twist torsion bar to raise vehicle



Untwist torsion bar to lower vehicle

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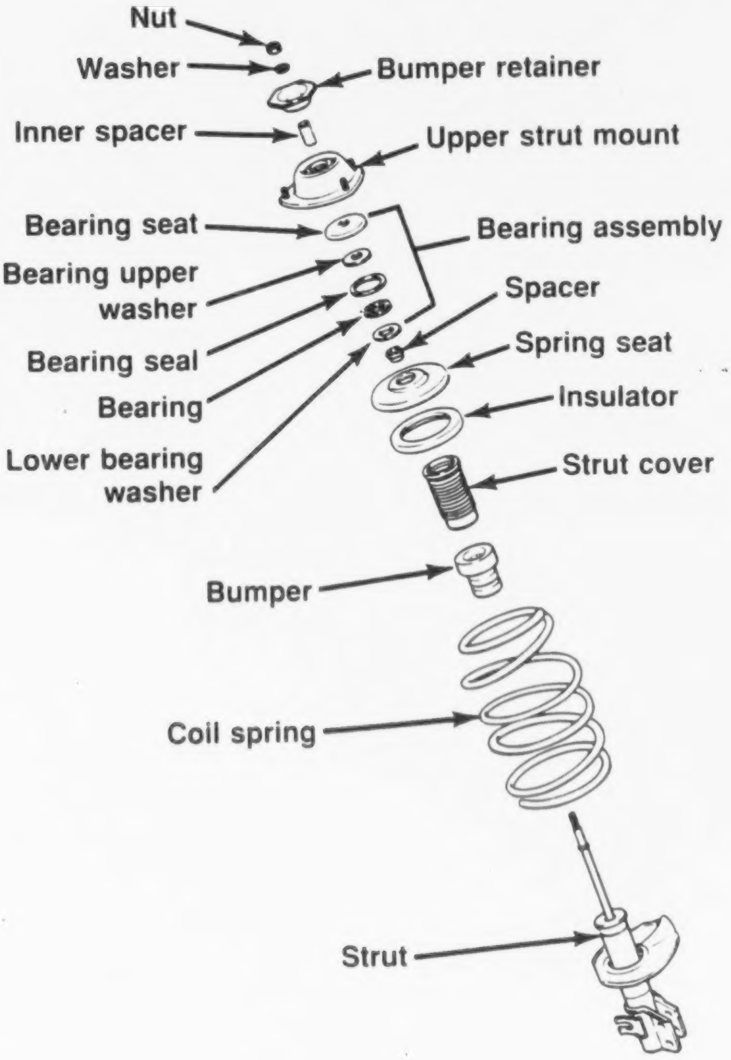
Exploded View of a MacPherson Strut


Nut
Washer
Bumper retainer
Inner spacer
Upper strut mount
Bearing seat
Bearing assembly
Bearing upper washer
Spacer
Bearing seal
Spring seat
Bearing
Insulator
Lower bearing washer
Strut cover
Bumper
Coil spring
Strut

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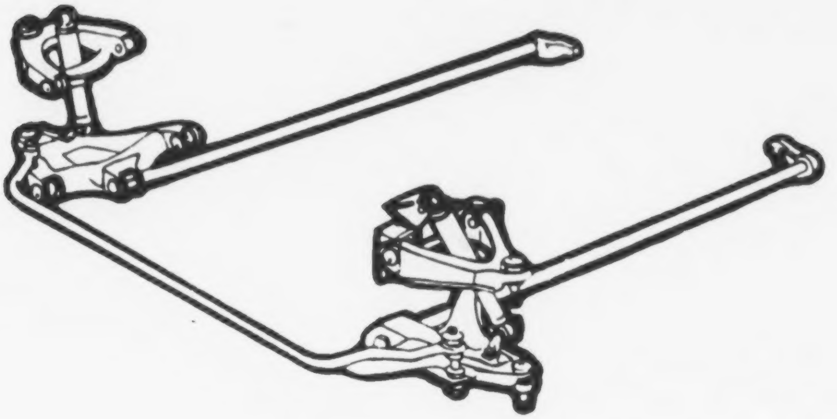
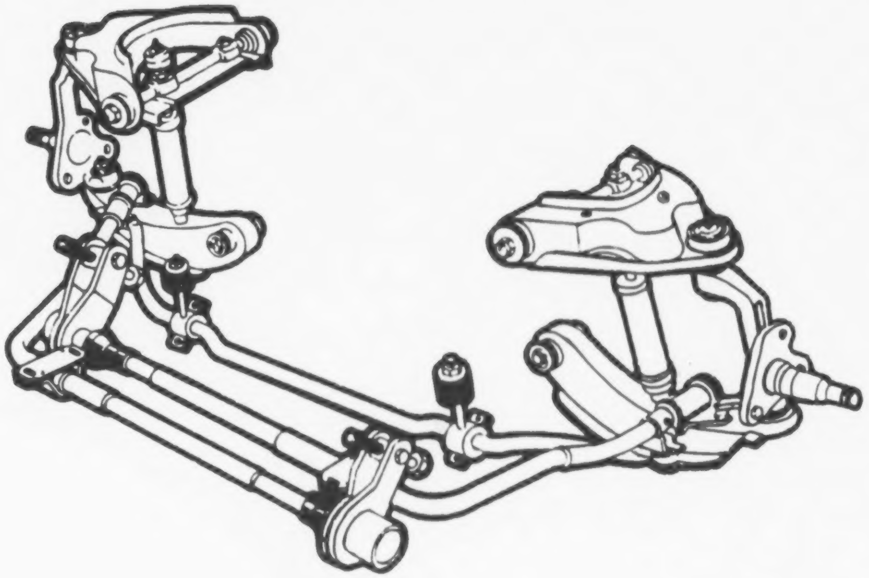
Types of Front Suspension

Longitudinal Torsion Bar



Transverse Torsion Bar



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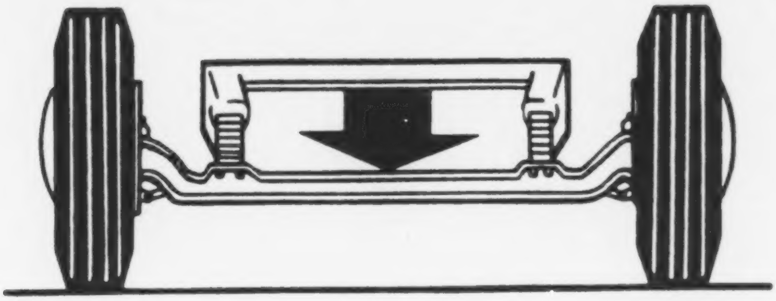
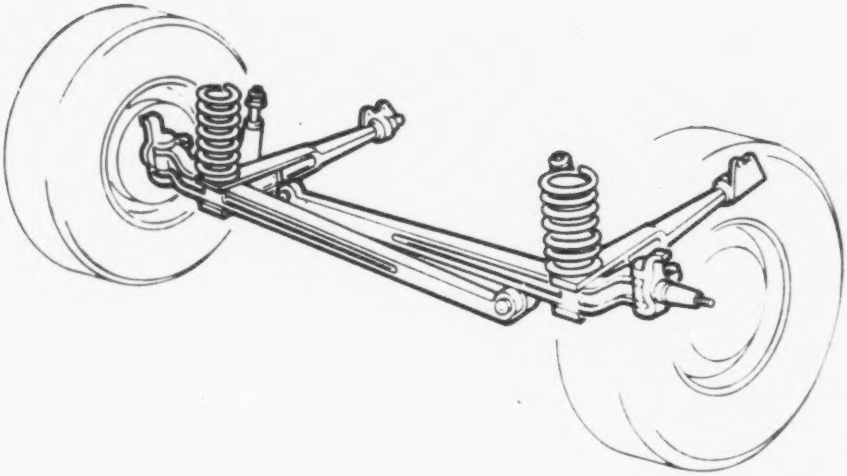
Types of Front Suspension

Straight Axle with Leaf Springs



Twin I-Beam



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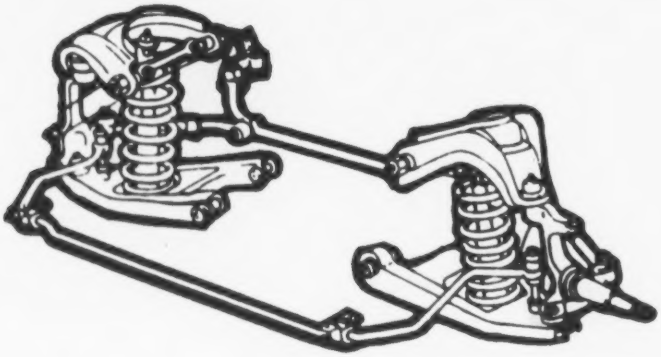
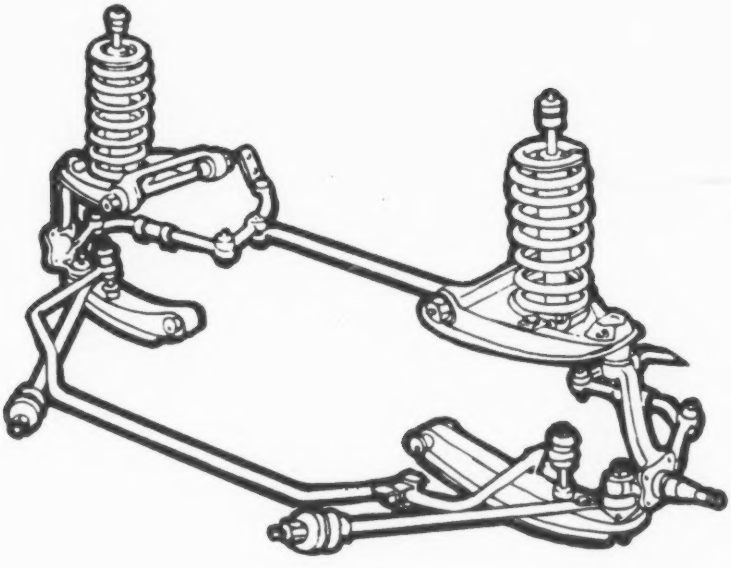
Types of Front Suspension

Coil Springs Seat on Lower Control Arm



Coil Springs Seat on Upper Control Arm



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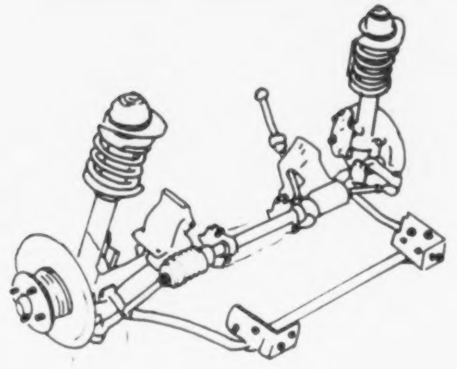
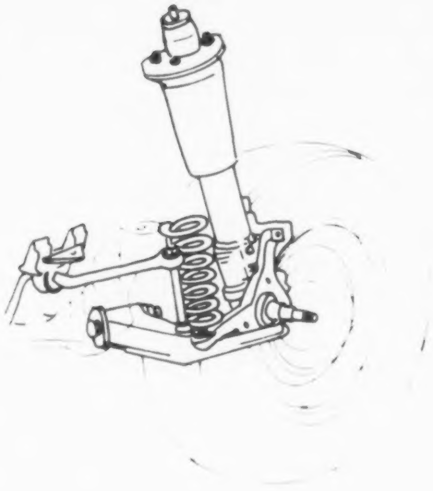
Types of Front Suspension

MacPherson Strut



Modified Strut



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ACTIVITY SHEET 1

SERVICE FRONT SUSPENSION SYSTEMS

III

NAME ______________________ SCORE ________

Answer general questions about front suspension systems.

INTRODUCTION

To become certified as a steering and suspension technician, you must pass a test on the steering and suspension systems compiled by the National Institute for Automotive Service Excellence. The certification test covers all aspects of the vehicle's steering and suspension systems. This activity sheet covers only front suspension systems, but it contains questions similar in content and style to those found on the actual ASE certification test.

After you have completed this activity sheet, get together with a group of your classmates and use the answer key to check your answers. Discuss the questions and their correct answers, paying particular attention to those that were answered incorrectly. Review any information that you do not understand.

DIRECTIONS

Read each of the following study questions twice. The second time you may notice a key word that you overlooked the first time. Every word in a question is important and may provide a clue to the right answer. Select the answer that is **most** correct and write its letter in the answer blank.

______1. With which of the following is a strut rod used?

A. Upper control arm attached to frame at one point
B. Lower control arm attached to frame at one point
C. Lower control arm attached to frame at two points
D. Upper control arm attached to frame at two points

______2. Leaf springs are **most** likely to be used on:

A. Truck front suspension systems
B. Passenger car front suspension systems
C. Compact car front suspension systems
D. All of the above

______3. Which of the following statements about assembling the stabilizer bar link assembly is **not** correct?

A. Install the bolt, bushings, washers, and sleeve in the reverse order of the manufacturer's instructions
B. Install the nut and finger-tighten; torque to specifications
C. Torque the stabilizer bar link fasteners after the vehicle has been lowered to the floor
D. Make sure the bolt is installed in the correct position

______4. The major difference between a MacPherson strut and a modified MacPherson strut is that on the:

A. Modified MacPherson strut, the coil spring is attached to the strut
B. Modified MacPherson strut, the shock absorber is inside the coil spring
C. Modified MacPherson strut, the coil spring is attached to the lower control arm
D. MacPherson strut, the coil spring is attached to the lower control arm

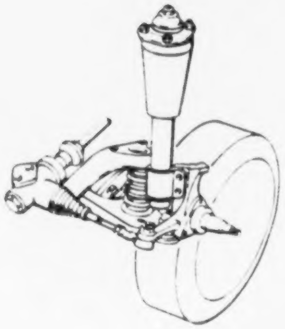
______5. Technician A says a short-and-long-arm suspension is a type of independent suspension. Technician B says it is not independent because the control arms differ in length. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______6. Technician A says transverse and longitudinal torsion bar suspension systems have the same basic components and operate in the same manner. Technician B says systems with longitudinal torsion bars have upper and lower control arms. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______7. What type of suspension system is illustrated below?



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A. Modified MacPherson strut
B. MacPherson strut
C. Short-and-long-arm coil spring
D. Torsion bar

______8. Technician A says a worn upper ball joint that is riveted into a control arm cannot be replaced and a new control arm with a new ball joint must be installed. Technician B says a riveted ball joint should be replaced with a ball joint that is attached with bolts. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______9. A short-and-long-arm suspension system which has a lower control arm attached to the frame at only one point usually has which of the following parts to stabilize the control arm?

A. Stabilizer bar
B. Torsion bar
C. Stabilizer length
D. Strut rod

_____10. Technician A says torsion bar gauges are used when adjusting vehicle height. Technician B says torsion bar adjustment is done at the upper control arm where the torsion bar is connected. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____11. When installing a steering knuckle, when should the retaining nuts be torqued?

A. The upper retaining nut should be torqued before the upper ball joint is connected, and the lower one should be torqued as soon as the lower ball joint is connected
B. The upper and lower retaining nuts should be torqued after the ball joints are connected and the vehicle is lowered to the floor
C. The upper and lower retaining nuts should be torqued just after both the upper and lower ball joints have been connected
D. The upper and lower retaining nuts should be torqued just after new cotter pins have been installed

_____12. Technicians A and B are discussing stabilizer bars on an SLA system. Technician A says the stabilizer bar is connected to both upper control arms and the vehicle frame. Technician B says the stabilizer bar is connected to the stabilizer link assemblies and the upper control arms. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____13. Technicians A and B are discussing coil springs. Technician A says coil springs for the left and right front are never interchangeable. Technician B says front coil springs should be replaced as a set. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____14. Technician A says when checking radial and axial play of control arm ball joints, the readings should be compared to the manufacturer's specifications. Technician B says only axial movement is checked. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

ACTIVITY ANSWERS

SERVICE FRONT SUSPENSION SYSTEMS III

ACTIVITY SHEET 1

1. B
2. A
3. C
4. C
5. A
6. C
7. A
8. B
9. D
10. A
11. C
12. D
13. B
14. A

ASSIGNMENT SHEET 1

SERVICE FRONT SUSPENSION SYSTEMS

III

NAME ______________________ SCORE ______

OBJECTIVE 14 **Diagnose front suspension system problems.**

INTRODUCTION

There are many different models of vehicles and many different suspension systems. One popular system that can be modified in several different ways is the short-and-long-arm suspension system.

Since many front-end problems may originate with either steering or suspension system parts, proper diagnostic procedure must be followed. The specialist should test drive the vehicle to verify the customer's complaint and inspect the vehicle. He or she can then determine the most likely cause of the problem and the necessary corrective action.

DIRECTIONS

Read each of the following questions carefully. Then using your knowledge of short-and-long-arm suspension parts and information from service manual diagnostic charts, select the answer that is **most** correct. Write the correct letters in the blanks.

______1. A customer complains his vehicle leans to the side when cornering. Which of the following is the **most** likely cause?

A. Both front coil springs are worn
B. Not enough sprung weight
C. Loose stabilizer bar
D. Flat tire

______2. When test driving a vehicle, you hear a clunking noise from the front end. Upon inspection you find that all ball joints, bushings, and tie-rod ends are fine. There also appear to be no problems with the steering system. Which of the following would **most** likely cause this noise?

A. Improperly adjusted torsion bars
B. Damaged timing chain
C. Damaged shock absorbers or mountings
D. Weak springs

_______3. When servicing a customer's vehicle, you find that the front coil springs are different. Which of the following was probably the customer's complaint?

A. Front-end noise
B. Ride too soft
C. Difficult steering
D. Uneven trim height

_______4. A customer complains of a clunk when applying the brakes. Which of the following could cause this condition?

A. Shock absorbers
B. Damaged stabilizer bar
C. Worn control arm bushings
D. Broken spring

_______5. You road test a vehicle to verify the customer's complaint that the front end bounces more than normal after driving over a bump. While driving, you notice excessive wheel tramp. What is the **most** likely cause of this problem?

A. Worn shock absorbers
B. Improperly lubricated ball joints
C. Too much tension on the torsion bars
D. Improper tire inflation

_______6. As a customer drives into your shop, you notice that the vehicle leans to one side. When you mention this to her, she says the springs were recently replaced. Which of the following could cause the vehicle to lean?

A. Worn control arm bushings on one side
B. Wheels out of balance
C. Non-matching springs
D. Loose springs

______7. A customer complains of vehicle shimmy. The vehicle's odometer reads 20,000 miles, and the tires are beginning to show signs of wear. Which of the following would you **most** likely expect to be the problem?

A. Worn strut rod bushings
B. Wheels out of balance
C. Incorrectly installed springs
D. Worn ball joints

______8. While test driving a customer's vehicle, you notice the suspension doesn't absorb road shock as it should. During inspection you find the control arms and bushings are in good conditions and the shock absorbers are okay. Which of the following could be the problem?

A. Worn ball joints
B. Loose tie-rod ends
C. Improper air spring inflation
D. Weak torsion bars

______9. A customer complains that his vehicle pulls to one side when driving. You also notice that the vehicle leans to that side. The tires are correct for the vehicle and are inflated properly. Which of the following could cause this condition?

A. Worn control arm bushings
B. Broken strut rod
C. Broken spring
D. Worn shock absorbers

______10. When servicing a customer's vehicle, you find that you must replace the control arm bushings and ball joints. Which of the following was the customer's complaint?

A. Steering wheel pull when braking
B. Wheel tramp
C. Ride too harsh
D. Difficult steering

ASSIGNMENT ANSWERS

SERVICE FRONT SUSPENSION SYSTEMS III

ASSIGNMENT SHEET 1

1. C
2. C
3. D
4. C
5. A
6. C
7. B
8. D
9. C
10. A

JOB SHEET 1

SERVICE FRONT SUSPENSION SYSTEMS

III

OBJECTIVE 15A

Inspect short-and-long-arm coil spring suspension system components.

INTRODUCTION

The first step in servicing the front suspension system is making a complete inspection. During the inspection, the service technician must be careful to note the condition of the different components and whether or not any should be replaced. By following a wheel alignment check sheet, the technician can be sure all steering and suspension parts are checked and all problems corrected before alignment. Without a good inspection, a loose or worn part that will affect vehicle handling, tire wear, or wheel alignment settings may be overlooked.

Ball joint inspections are almost identical for upper and lower control arms. However, load-carrying and non-load-carrying ball joints differ, depending on the location of the spring. If the spring is located on the lower control arm, the lower ball joint is the load-carrying ball joint, and the upper ball joint is the non-load-carrying ball joint. If the coil spring is located on the upper control arm, just the opposite is true.

EQUIPMENT AND MATERIALS

- Vehicle
- Appropriate service manual
- Eye protection
- Wheel alignment check sheet
- Pry bar
- Hydraulic lift
- Jacks or jack stands
- Flat-blade screwdriver
- Measuring tape or stick
- Pen or pencil and paper
- Shop towels
- Wheel alignment rack

NOTE: Sometimes these inspections are performed while the vehicle is on a wheel alignment rack. Your instructor will indicate whether the vehicle should be on an alignment rack.

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

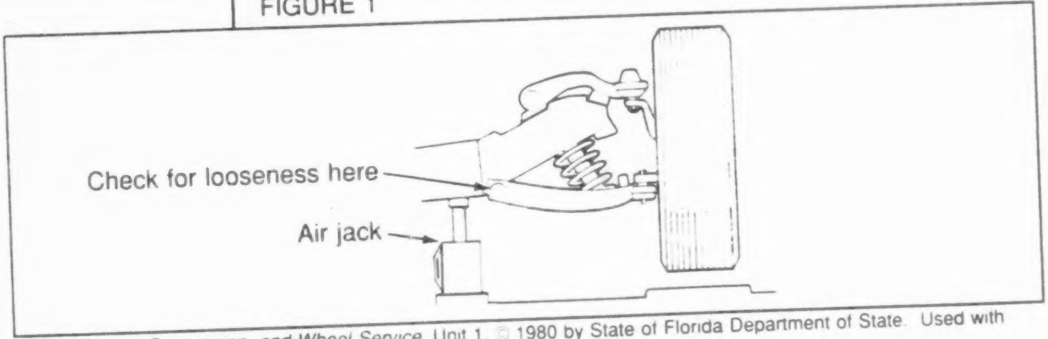
PROCEDURE

Inspect short-and-long-arm coil spring suspension system components

1. Make sure the wheel bearings are properly adjusted before the inspection. It is important that the bearings not be loose, or it may be difficult to determine if the ball joints are worn.
2. Push up and down on each corner of the car and count the number of "bounces" the car makes. Three or fewer bounces indicates good shocks; more than three indicates shock problems.
3. Visually check the shocks.
    - Check for signs of damage or leaking oil.
    - Check the rubber bushings for damage or splits.
4. Inspect the ball joints according to the manufacturer's instructions.
5. Raise the vehicle and support as recommended by the manufacturer.
6. Visually inspect each lower control arm assembly for any of the following defects:
    - Frayed, split, or cracked bushings
    - Cracked or damaged lower control arm
    - Bent or damaged end of inner shaft
    - Loose washers
    - Loose control arm mounting
    - Center line of bottom shaft not in center line of bushing
7. If any parts are defective, they should be replaced; if the mounting bolts are loose, they should be tightened.
8. Pry the control arms back and forth to check for excessive looseness, inserting the pry bar between the frame or body and the control arm.
9. Grasp the front of one wheel and turn it outward until you reach the wheel stop.

10. Gently bounce the wheel off the wheel stop and check for movement and a clicking noise at the inner shaft and bushings of the lower control arm. (Figure 1)

FIGURE 1


Check for looseness here
Air jack

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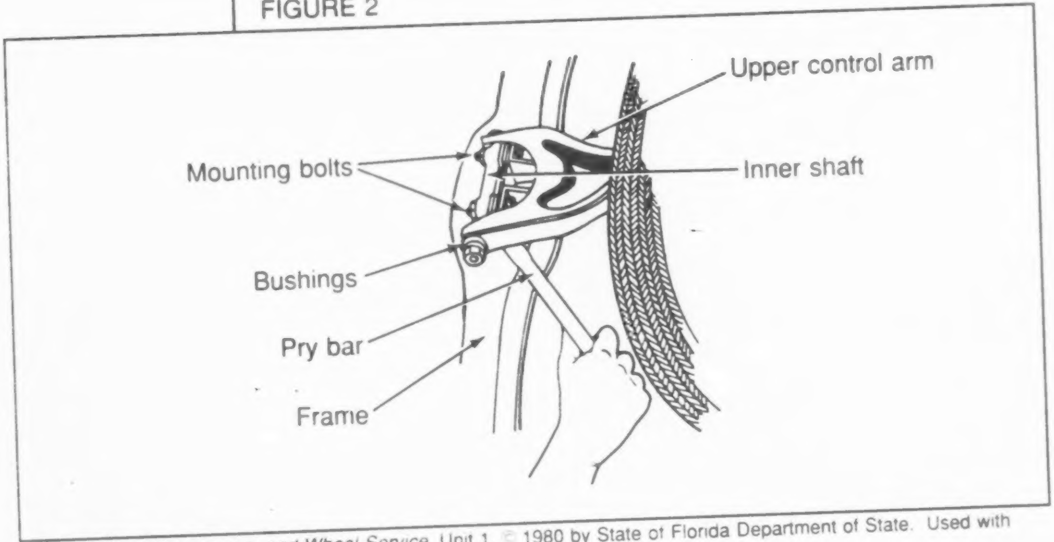
11. If excessive movement is observed, the bushings should be replaced or other repairs made.

12. Be sure the inner shaft mounting bolts are tight before inspecting the upper control arms for looseness.

    NOTE: By doing so, you eliminate the possibility of confusing the looseness of the inner shaft mounting bolts with shaft and bushing wear.

13. Place a pry bar between the inner shaft of the upper control arm and the frame or body. (Figure 2)

FIGURE 2


Upper control arm
Mounting bolts
Inner shaft
Bushings
Pry bar
Frame

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CAUTION

Be sure the pry bar is secure before prying so you don't damage other parts.

14. Move the bar up and down, looking for movement at the upper control arm, inner shaft, and bushings.

15. If movement is observed, the inner shaft and/or the bushings should be replaced.

16. Visually inspect the rebound bumpers on the control arms for cracks, fraying, or damage.

17. If the bumpers are defective, they should be replaced.

18. Remove the jack stands or lower the vehicle to the floor.

19. Be sure the vehicle is prepared according to the manufacturer's directions, such as a full fuel tank, no load in the trunk, etc., before taking measurements.

20. Use a measuring tape to measure the height of the vehicle to determine whether the coil springs have sagged.

21. If the measured height is lower than that specified by the vehicle manufacturer, the coil springs should be replaced.

22. Raise the vehicle on a hydraulic lift.

23. Visually inspect the coil springs for damage.

    NOTE: Damage could be caused by coils rubbing on the body and frame, or broken or distended coils.

24. If damage is found, the coil spring should be replaced.

25. Visually inspect the spring insulators.

    NOTE: The spring insulators are the plastic or rubber plates between the frame or body and the coil springs.

26. If the spring insulators are damaged, they should be replaced.

27. Lower the vehicle to the floor.

28. Visually check the strut rod bushings for damage or wear. If the bushings are damaged or badly worn, they should be replaced.

29. Attempt to move the strut rod back and forth with a pry bar. If there is any excessive movement, the bushings should be replaced.

30. Visually inspect the strut rod to see if it is bent or damaged in any way. If the strut rod is bent or damaged, it should be replaced.

31. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 2

SERVICE FRONT SUSPENSION SYSTEMS

OBJECTIVE 15B

Repair a short-and-long-arm suspension system.

INTRODUCTION

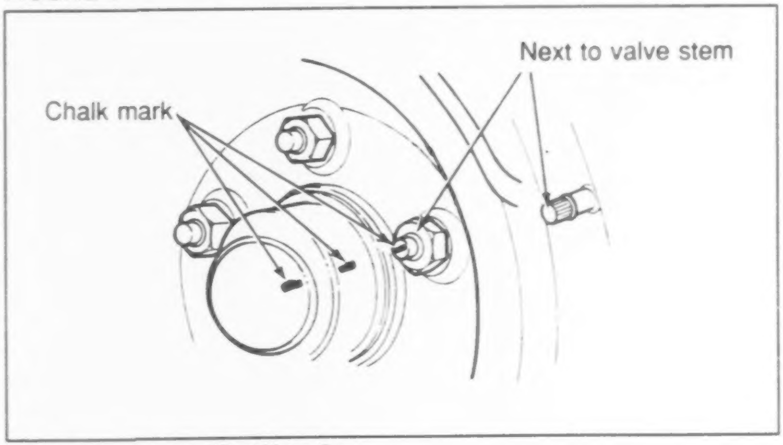
Short-and-long-arm (SLA) suspension systems are used in many American-made vehicles. Repairing a short-and-long-arm suspension system involves replacing those parts and components that are damaged or worn. Parts that may be replaced include control arms, ball joints, coil springs and insulators, and control arm bushings.

Because of the variety of types of short-and-long-arm suspension systems, the manufacturer's service manual must be used to repair the system. The following guidelines will be useful on most models.

Guidelines:

- To insure that balanced wheels are reinstalled in the same position, mark each wheel with chalk or a marker. (Figure 1)

FIGURE 1



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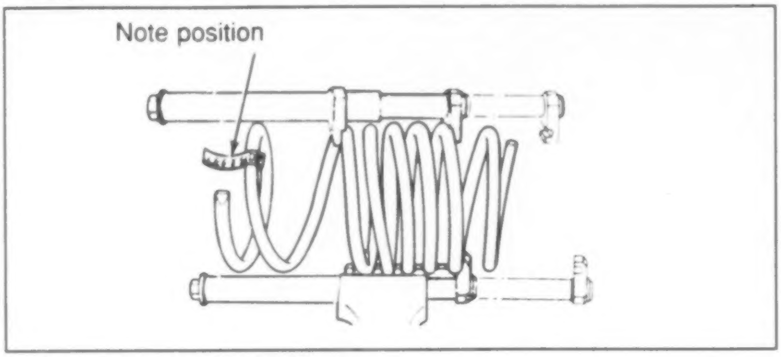
- The control arm ball joints must be unloaded before they are disconnected.
- For servicing some SLA suspension systems, some steering and brake assemblies may need to be removed. Refer to specific service manuals for the correct procedures.

- Coil spring compressing tools should be used only according to manufacturers' instructions. A coil spring that is suddenly released can cause personal injury or equipment damage. One type of coil spring compressing tool is shown in Figure 2.

FIGURE 2



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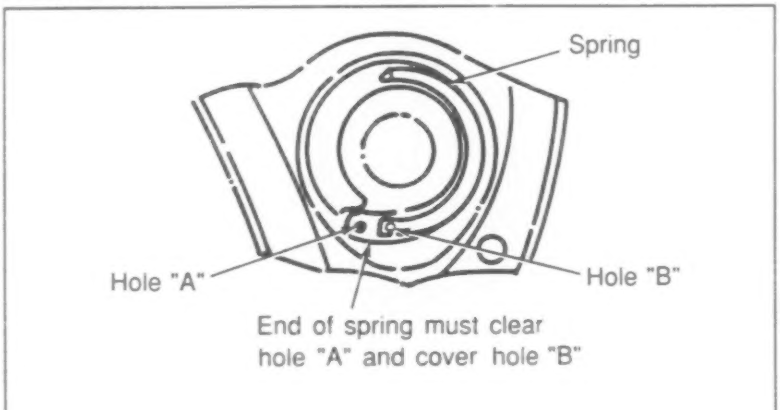
- Coil springs should be replaced as a set. If one front coil spring is replaced, the other front spring should be replaced too.

- Be sure replacement coil springs are installed at the proper location. Incorrectly positioned coil springs can affect both the suspension and the alignment. Usually there are two holes in the spring seat, one of which should be covered or partially covered by the spring, as shown in Figure 3.

FIGURE 3



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- After servicing a vehicle's short-and-long-arm suspension system, the front-end alignment should be checked before the vehicle can be considered road ready.

EQUIPMENT AND MATERIALS

- Vehicle
- Appropriate service manual
- Other equipment and materials as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

JOB SHEET 3

SERVICE FRONT SUSPENSION SYSTEMS

III

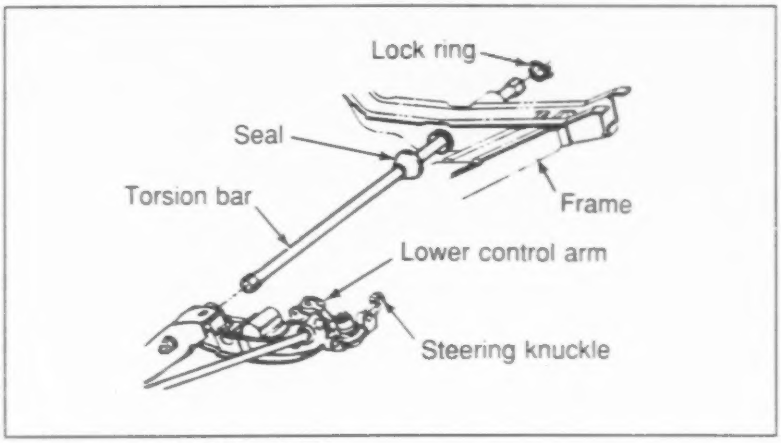
OBJECTIVE 15C

Inspect, replace, and adjust front suspension system torsion bars.

INTRODUCTION

A front suspension system with torsion bars requires service similar to that required for a short-and-long-arm suspension system. This is because both systems have control arms, and both perform the functions of an independent suspension. However, torsion bars, rather than coil springs, provide the necessary spring action. In addition to the skills needed to service short-and-long-arm coil-spring suspension systems, the steering and suspension technician will also need to have the skills necessary to inspect, replace, and adjust front suspension system torsion bars and mountings.

FIGURE 1



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In this system, the vehicle riding height is changed by adjusting the torsion bars. An adjusting bolt is located at the anchor end of the torsion bar. It is important that this adjustment is made before making any wheel alignment adjustments.

Torsion bar adjustment consists of changing and comparing the heights of both sides of the vehicle. The torsion bars are adjusted so the height of each side is within a range specified by the vehicle manufacturer, and the measurements of the two sides of the vehicle are within a certain range of each other. Usually, the difference between the sides can be no more than one-eighth of an inch.

Compare the measurements of both sides after adjusting the torsion bars. This is necessary because the adjustment of one side will affect the height of the other side.

Refer to the vehicle manufacturer's service manual for points where measurements are to be taken. Use either a tape measure or a torsion bar gauge to obtain the necessary measurements. Usually the distance between the floor and the control arm or the frame is measured.

EQUIPMENT AND MATERIALS

- Vehicle
- Appropriate service manual
- Eye protection
- Tape measure or torsion bar gauges
- Hydraulic lift or jack and jack stands
- Basic hand tool set
- Torsion bar removing tool
- Needle-nose pliers
- Hammer
- Replacement parts as necessary
- Shop towels
- Chassis lubricant
- Wheel alignment check sheet
- Pen or pencil

NOTE: Be sure to record all inspection findings on your wheel alignment check sheet.

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

PROCEDURE

Inspect torsion bars

1. Raise the vehicle and support it safely so there is no load on the suspension.

   NOTE: If jacks and stands are used, the stands should be placed under the frame. This allows the wheels to hang down from the vehicle and insures there is no strain on the torsion bars.

2. Inspect the torsion bars and mounting parts for cracks, wear, or loose or missing parts.

3. Inspect the bushings and rubber insulators if the vehicle is equipped with transverse torsion bars.

   NOTE: Transverse torsion bars have bushings at the control arm and pivot cushion bushings where the midsection of the bars are secured to the frame crossmember. These cushion bushings help reduce vibration and prevent the squeaking sound caused by metal-to-metal contact.

4. Release the torsion bar load by loosening the torsion bar adjusting bolts.

   NOTE: On earlier model cars that are adjusted with clamps, it will be necessary to have the help of an assistant and use a special bar-type tool to adjust the clamps. Also, on some vehicles a special tool is used to release the tension on the adjusting bolt before it can be loosened or removed.

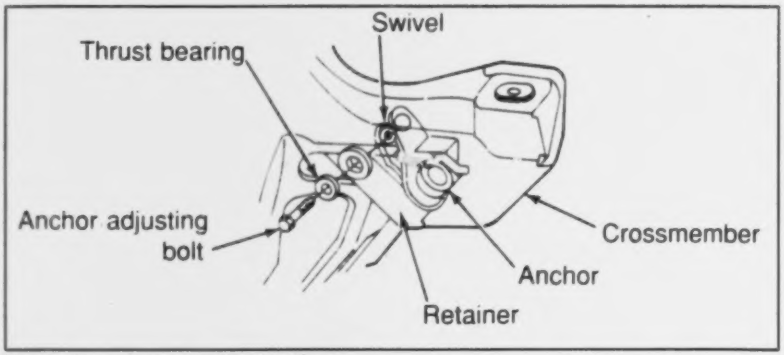
PROCEDURE

Remove torsion bars on vehicles equipped with transverse torsion bars

1. Remove the adjusting bolt and thrust bearing and lower the torsion bar and anchor assembly from the retainer at the frame crossmember. (Figure 2)

   NOTE: The retainer is attached to the frame crossmember and is **not** removed with the anchor assembly.

FIGURE 2



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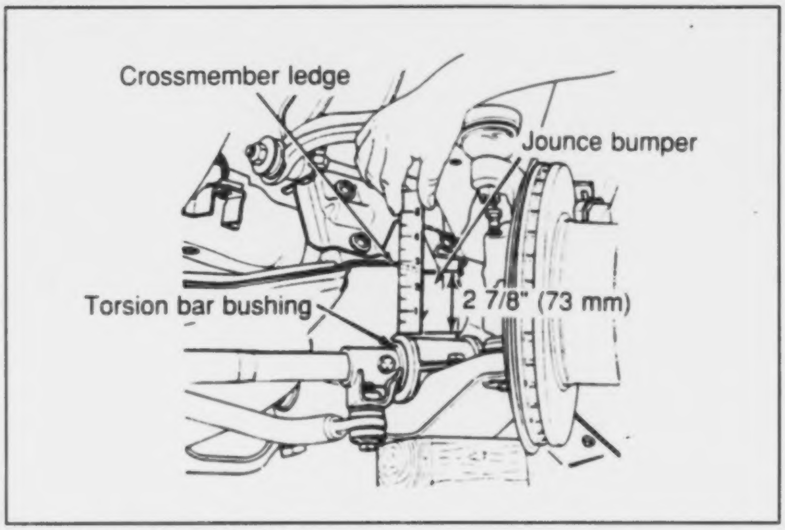
2. Raise the lower control arm to the height specified by the vehicle manufacturer.

   NOTE: The manufacturer usually specifies the control arm be raised to leave a certain clearance between the frame and the torsion bar bushing at the lower control arm. (Figure 3)

   EXAMPLE: Measurement for one type of rear-wheel drive vehicle (Figure 3)

FIGURE 3



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3. Disconnect the stabilizer bar from the lower control arm.

4. Disconnect the torsion bar from the lower control arm by removing the bolts attaching the bushing to the control arm.

   NOTE: The torsion bar can be removed from the bushing, leaving the bushing on the control arm. However, it is easier to remove the bar and bushing together. Replacement torsion bars usually come with bushings installed.

5. Disconnect the pivot bushing from the frame and remove the torsion bar assembly.

   NOTE: The pivot bushing is attached to the torsion bar. This bushing, unlike the one on the control arm, must be removed with the torsion bar.

6. Remove the balloon seal from the torsion bar.

   CAUTION

   Remove the balloon seal carefully. If it is not damaged, it may be used again.

PROCEDURE

Remove torsion bars on vehicles equipped with longitudinal torsion bars

NOTE: These next steps outline the procedure for removing a longitudinal torsion bar by sliding it out the rear side of the frame crossmember. On some vehicles with this type of suspension, there is only an opening on one side of the frame crossmember, and the torsion bar cannot be passed through it. For torsion bar removal and replacement on these vehicles, refer to the vehicle manufacturer's service manual.

1. Use needle-nose pliers to remove the lock ring from the anchor end of the torsion bar. (Refer to Figure 1.)

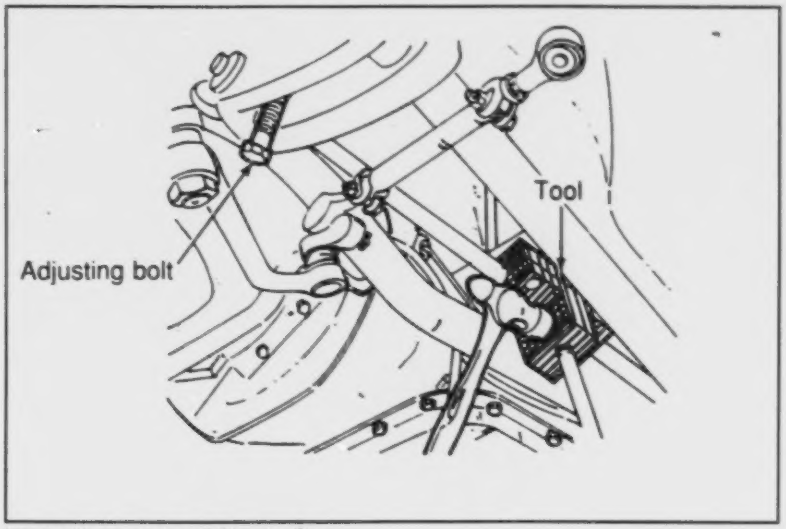
   NOTE: This lock ring secures the torsion bar in the anchor, preventing it from slipping out.

2. Place the torsion bar removing tool around the center section of the torsion bar and tighten the clamping bolts on the tool to secure it.

3. Strike the removing tool with a hammer, directing the hammer blows to the vehicle front, to release the torsion bar from the control arm and frame. (Figure 4)

   NOTE: At this step, only the ends of the torsion bar are freed from their connections. The torsion bar itself is not yet removed.

FIGURE 4



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4. Loosen the clamping bolts on the torsion bar removing tool and remove the tool from the torsion bar.

5. Apply a light coat of chassis lubricant to the torsion bar.

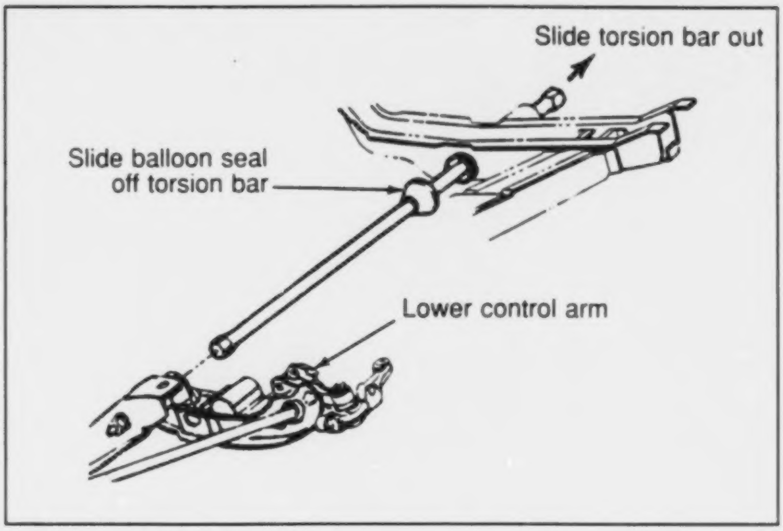
   NOTE: Lubricating the torsion bar will make it easier to slide out through the opening at the anchor end.

6. Slide the bar out through the frame opening, allowing the balloon seal to slide off the bar as the bar passes through the opening. (Figure 5)

   CAUTION

   Remove the balloon seal carefully. If it is not damaged, it may be used again.

FIGURE 5



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PROCEDURE

Replace torsion bars

1. Inspect the torsion bar, bushings, adjusting bolt, balloon seal, and anchor assembly for damage or wear; if any are damaged or worn, obtain replacement parts meeting the manufacturer's specifications.

2. Check the torsion bar ends and openings in the frame crossmember and control arm to be sure they are clean and free from dirt and grease.

3. Install the torsion bars on the sides of the vehicle for which they are intended, following the manufacturer's instructions.

   NOTE: Torsion bars do not have to be replaced in pairs.

4. Check the tires to be sure they are of the same size and are properly inflated.

5. Make sure the vehicle is at the correct riding height and curb height, as listed in the manufacturer's service manual.

   NOTE: Either torsion bar gauges or a tape measure can be used. Gauges can be left in place while the torsion bars are adjusted. The vehicle should have a full tank of gas and be on a level surface. Other conditions may also have to be met.

6. Jounce the vehicle several times and allow the vehicle to come to a rest.

7. Measure the vehicle height at the points specified in the vehicle service manual.

8. Compare the height readings from each side of the vehicle with the manufacturer's specifications.

9. If the reading is not within specifications, note whether the reading is higher or lower than the height specified.

PROCEDURE

Adjust torsion bars

1. Lubricate the torsion bar adjusting bolts with a chassis lubricant.

2. If the vehicle height is lower or higher than the manufacturer's specifications, turn the adjusting bolts according to the manufacturer's directions to raise or lower the vehicle.

   NOTE: On most vehicles, the adjusting bolts are turned clockwise to raise the vehicle, and counterclockwise to lower it. This will vary, depending on the placement of the adjusting bolt. Always refer to the vehicle manufacturer's service manual.

3. Jounce the vehicle and allow the vehicle to come to rest.

4. Measure the height on both sides of the vehicle; compare the measurements with specifications.

5. Compare height readings of both sides of the vehicle.

6. Continue the adjusting procedure until the measurements and difference in measurements of both sides are within specifications.

7. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 4 — SERVICE FRONT SUSPENSION SYSTEMS

OBJECTIVE 15D

Inspect and replace the stabilizer bar, bushings, brackets, and links.

INTRODUCTION

The stabilizer bar, sometimes called a sway bar, is a spring steel bar that connects the lower control arms. It controls body roll as the vehicle turns or travels over uneven surfaces by transferring a portion of the load from one wheel to another. Servicing includes replacing the stabilizer bar links, bushings, or brackets.

Guidelines:

- If link replacement is necessary, replace the entire stabilizer, bar link assembly, bushings, bolt, and sleeve.
- If the stabilizer bar is replaced, also replace the mounting bushings and brackets.
- Torque the frame mounting bolts to specifications after the vehicle is lowered to the floor.

EQUIPMENT AND MATERIALS

- Vehicle
- Appropriate service manual
- Other equipment and materials as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

JOB SHEET 5 SERVICE FRONT SUSPENSION SYSTEMS III

OBJECTIVE 15E

Inspect a twin I-beam suspension system.

INTRODUCTION

Another type of front suspension system is the I-beam. There are several varieties of I-beam systems. Some use kingpins, others use ball joints. It is important that all inspection and servicing follows the manufacturer's instructions.

EQUIPMENT AND MATERIALS

- Vehicle
- Appropriate service manual
- Other equipment and materials as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

JOB SHEET 6

SERVICE FRONT SUSPENSION SYSTEMS

III

OBJECTIVE 15F

Inspect, remove, and replace MacPherson strut type suspension system components.

INTRODUCTION

Front-wheel drive vehicles are very popular. Most of these vehicles have MacPherson or modified MacPherson strut suspensions. For this reason, it is important that the steering and suspension technician know how to properly service this type of suspension system.

When servicing a MacPherson strut suspension system, always perform two inspections, one while the struts are still on the vehicle and another after the struts are removed. Before removal, a bounce test and visual inspection should be performed. After removal, the bearings, boot, bumper, and all other parts should be checked.

If the system is in poor condition MacPherson struts are usually replaced, but some can be repaired. Replace struts in pairs.

EQUIPMENT AND MATERIALS

- Vehicle
- Appropriate service manual
- Other equipment and materials as required by

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

JOB SHEET 1

Inspect short-and-long-arm coil spring suspension system components.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained the proper equipment and materials.	_____	_____
2. Prepared the vehicle and work area appropriately.	_____	_____
3. Completed the inspection, following the outlined procedures.	_____	_____
4. Observed safety rules and precautions.	_____	_____
5. Cleaned the work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 2

Repair a short-and-long-arm suspension system.

STUDENT'S NAME ________________ DATE __________

EVALUATOR'S NAME ______________ ATTEMPT NO. ____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained the proper equipment and materials.	____	____
2. Prepared vehicle and work area appropriately.	____	____
3. Completed the procedures, following service manual instructions.	____	____
4. Observed safety rules and precautions.	____	____
5. Cleaned the work area and returned equipment and materials to proper storage.	____	____

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 3

Inspect, replace, and adjust front suspension system torsion bars.

STUDENT'S NAME ____________________ DATE __________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained the proper equipment and materials.	______	______
2. Prepared the vehicle and work area appropriately.	______	______
3. Referred to the vehicle manufacturer's service manual as necessary throughout the procedure.	______	______
4. Inspected torsion bars correctly.	______	______
5. Replaced torsion bars correctly.	______	______
6. Adjusted torsion bars correctly.	______	______
7. Observed safety rules and precautions.	______	______
8. Cleaned the work area and returned equipment and materials to proper storage.	______	______

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

____

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 4

Inspect and replace the stabilizer bar, bushings, brackets, and links.

STUDENT'S NAME ______________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained the proper equipment and materials.	_____	_____
2. Prepared the vehicle and work area appropriately.	_____	_____
3. Completed the procedures, following service manual instructions.	_____	_____
4. Observed safety rules and precautions.	_____	_____
5. Cleaned the work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

SERVICE FRONT SUSPENSION SYSTEMS

JOB SHEET 5

Inspect a twin I-beam suspension system.

STUDENT'S NAME ________________ DATE ____________

EVALUATOR'S NAME ________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained the proper equipment and materials.	_____	_____
2. Prepared the vehicle work area appropriately.	_____	_____
3. Completed the inspection, following service manual instructions.	_____	_____
4. Observed safety rules and precautions.	_____	_____
5. Cleaned the work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

404

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 6

Inspect, remove, and replace MacPherson strut type suspension system components.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained the proper equipment and materials.	_____	_____
2. Prepared the vehicle and work area appropriately.	_____	_____
3. Completed the procedures following service manual instructions.	_____	_____
4. Observed safety rules and precautions.	_____	_____
5. Cleaned the work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

____

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

WRITTEN TEST

SERVICE FRONT SUSPENSION SYSTEMS III

NAME ______________________________ SCORE ________

OBJECTIVE 1

Select the definitions of terms associated with front suspension system service. Write the correct letters in the blanks.

______1. **steering knuckle**

A. Connection that joins the steering and suspension components to allow the necessary pivoting and flexing of the components
B. Suspension component connected to the steering gearbox and the tire and wheel assembly
C. Suspension component attached to the upper and lower control arms and to the tie-rod ends by ball joints
D. Connection that joins the steering gearbox to the frame

______2. **rebound**

A. Position of the wheel when the wheel has moved upward from its normal position
B. Wheel downward movement from its normal position
C. Compressed position of the coil spring
D. Position parallel to the shaft

______3. **jounce**

A. Compressed position of the coil spring
B. Position of the wheel when the wheel has moved downward from its normal position
C. Extended position of the coil spring
D. Upward movement of the wheel

______4. **unsprung weight**

A. Weight of the parts that are *not* supported by suspension system
B. Weight of the parts supported by the suspension system
C. Compressed position of the coil spring
D. Pressure needed to stretch a coil spring

______5. **ball joints**

A. Parts that join the steering and suspension components to allow the necessary pivoting or movement of components
B. Suspension components attached to the inner and outer control arms and to the tie-rod ends
C. Suspension component connecting the vehicle frame and the steering knuckle; acts as a hinge to allow up-and-down movement of the tire and wheel assembly
D. Parts that support the weight of the suspension

______6. **independent suspension**

A. System in which both wheels attach to the same, straight axle; movement of one wheel affects the other wheel
B. System that allows the front suspension to operate independently of the rear suspension; movement of the front wheels does not directly affect rear wheels
C. System that allows the suspension components on one side of the vehicle to move independently of the other side; movement of one wheel does not affect the other wheel
D. System with the front wheels connected to different I-beams and a coil spring mounted between each I-beam and the frame; movement of one wheel does not directly affect the other wheel

______7. **short-and-long-arm suspension**

A. System in which both wheels attach to the same straight axle; movement of one wheel affects the other wheel
B. System with short upper and longer lower control arms
C. System with short lower and longer upper control arms
D. System that allows the front suspension to operate independently of the rear suspension; movement of the front wheels does not directly affect the rear wheels

______8. **suspension**

A. Vehicle system that transfers motion of the steering wheel to the wheels
B. Vehicle system designed to allow the driver control of the vehicle
C. Vehicle component to which tire and wheel assemblies are connected
D. Vehicle system that connects the wheels and the vehicle body, carries vehicle load, maintains body height, absorbs road shock, and provides directional control

______9. **control arm**

A. Suspension component attached to the upper and lower control arms and to the tie-rod end by means of ball joints
B. Vehicle system that connects the wheels and the vehicle body, absorbs road shock, and provides directional control
C. Suspension component connecting the vehicle frame and the steering knuckle; acts as a hinge to allow up-and-down movement of tire and wheel assembly
D. Suspension component that joins the steering and suspension systems

_____10. **sprung weight**

A. Weight of the parts that are *not* supported by the suspension system
B. Weight of the parts supported by the suspension system
C. Extended position of the coil spring
D. Amount of pressure necessary to compress a spring

_____11. **spring rate**

A. Measure of the weight needed to compress a spring
B. Vehicle weight that can be supported by a coil spring
C. Weight of the parts that are supported by the springs
D. Diameter of the metal coil in a coil spring

_____12. **nonindependent (solid-axle) suspension**

A. System having both upper and lower control arms and either coil springs or torsion bars
B. System in which the movement of one tire affects the tracking of another tire
C. System that allows suspension components to move independently of each other; movement of one wheel does not directly affect the other wheel
D. System in which both wheels attach to the same straight axle; movement of one wheel affects the other wheel

_____13. **axial**

A. Attached to the shaft
B. Perpendicular to the shaft
C. Intersecting the shaft
D. Parallel to the shaft

_____14. **radial**

A. Parallel to the shaft
B. Perpendicular to the shaft
C. Intersecting the shaft
D. Attached to the shaft

_____15. **vehicle (curb) height**

A. Height of the axle when the tires are normally filled
B. Distance between a flat, level surface and points on the vehicle
C. Distance from the ground to the highest point of the frame
D. Distance from the ground to the lowest point of the vehicle

OBJECTIVE 2 State the purposes of a front suspension system.

1. ____
2. ____
3. ____
4. ____
5. ____

OBJECTIVE 3 List the types of springs used in front suspension systems.

1. ____
2. ____
3. ____

OBJECTIVE 4

Describe the types of front suspension systems.

1. Torsion bar suspension: ______________________________

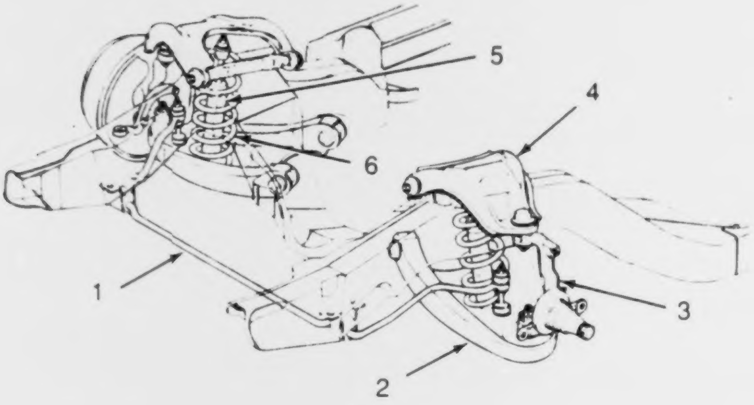
2. Twin I-beam suspension: ______________________________

3. Leaf spring suspension: ______________________________

4. MacPherson strut suspension: ______________________________

5. Short-and-long-arm coil spring suspension: ______________________________

OBJECTIVE 5 **Label the parts of a short-and-long-arm suspension system.** Write the letter of the part indicated in the blank.



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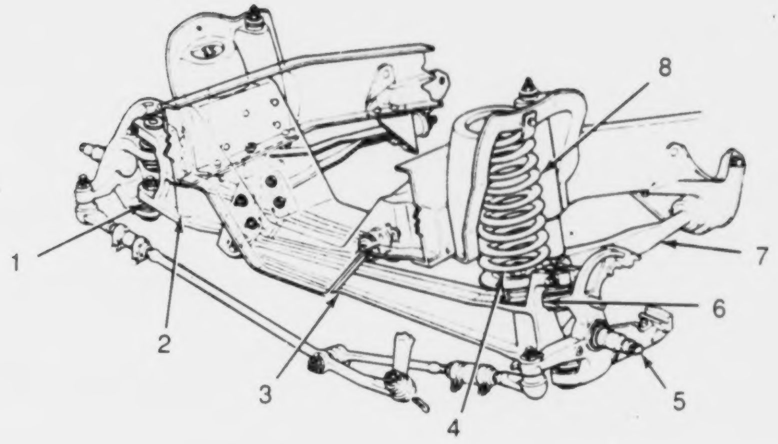
_______1.	A.	Lower control arm
_______2.	B.	Shock absorber
_______3.	C.	Spring
_______4.	D.	Stabilizer bar
_______5.	E.	Steering knuckle
_______6.	F.	Upper control arm

OBJECTIVE 6 **Label the parts of a twin I-beam suspension system.** Write the correct letter in the blank.



Used with permission of Ford Motor Co.

______1. A. Coil spring

______2. B. Left axle

______3. C. Lower ball joint

______4. D. Radius arm

______5. E. Right axle

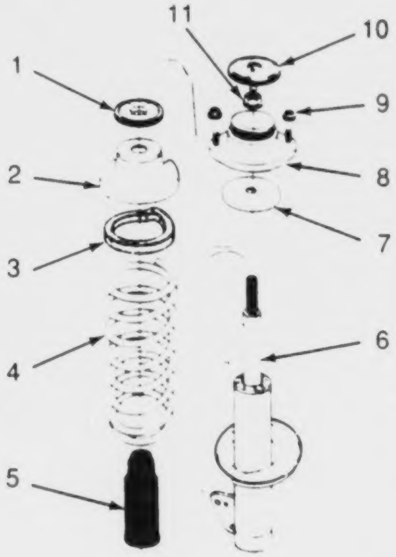
______6. F. Shock absorber

______7. G. Upper ball joint

______8. H. Wheel spindle

OBJECTIVE 7

Label the parts of a MacPherson strut suspension system.
Write the correct letter in the blank.



Used with permission of Ford Motor Co.

______1. A. Bearing and seal

______2. B. Dust cap

______3. C. Front jounce bumper

______4. D. Nut

______5. E. Nut and washer

______6. F. Shock absorber strut

______7. G. Spring

______8. H. Spring insulator

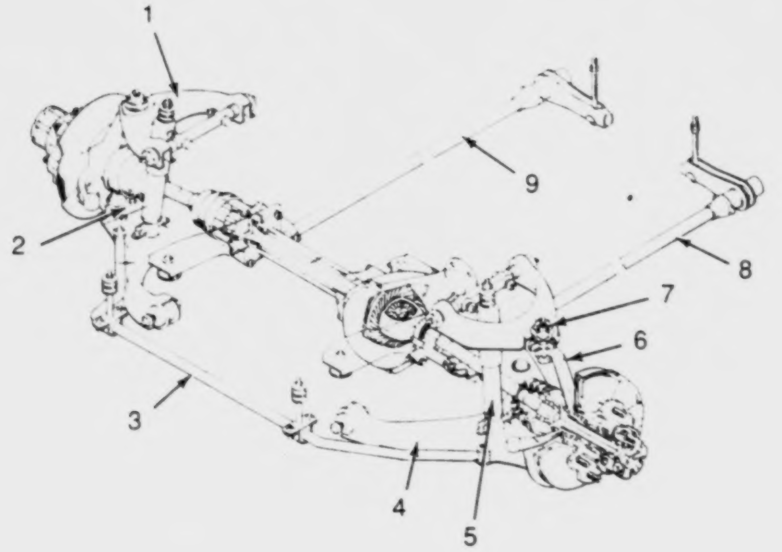
______9. I. Spring seat

_____10. J. Thrust plate

_____11. K. Upper mount

OBJECTIVE 8 **Label the parts of torsion bar suspension systems.** Write the correct letter in the blank.

LONGITUDINAL



Used with permission of Chrysler Corp.

_______1. A. Left torsion bar

_______2. B. Lower ball joint

_______3. C. Lower control arm

_______4. D. Right torsion bar

_______5. E. Shock absorber

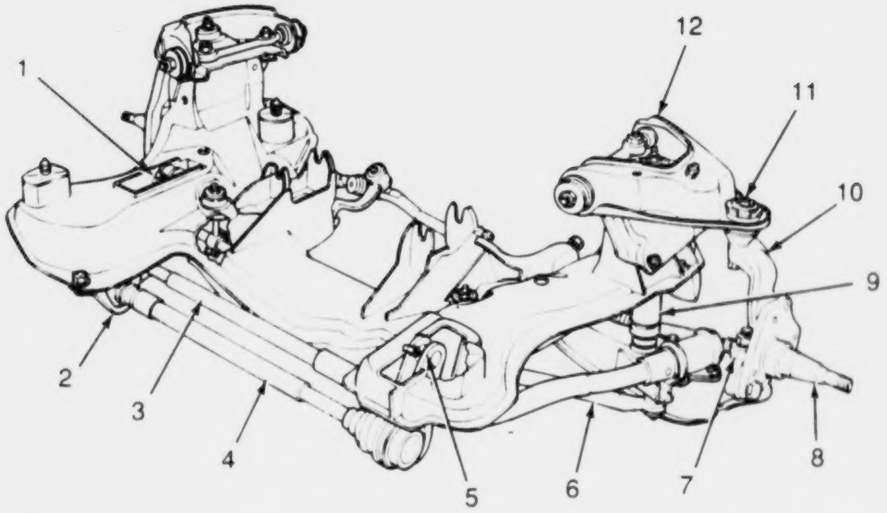
_______6. F. Stabilizer bar

_______7. G. Steering knuckle

_______8. H. Upper ball joint

_______9. I. Upper control arm

TRANSVERSE



Used with permission of Chrysler Corp.

_______1. A. Left torsion bar

_______2. B. Left torsion bar anchor

_______3. C. Lower ball joint

_______4. D. Pivot bushing

_______5. E. Right torsion bar

_______6. F. Right torsion bar anchor

_______7. G. Shock absorber

_______8. H. Spindle

_______9. I. Stabilizer bar

______10. J. Steering knuckle

______11. K. Upper ball joint

______12. L. Upper control arm

OBJECTIVE 9

Match front suspension system parts to their purposes. Write the correct letter in the blank.

_______1. Provides wheel connection to the suspension and to the tie-rod ends for steering; provides a place to mount the wheel so the wheel can pivot

_______2. Connects the steering knuckle to the control arm and provides swivel points

_______3. Prevents the car body from leaning excessively in sharp turns

_______4. Connects the body or frame to the steering knuckle

_______5. Keeps the lower control arm from moving toward the front or rear of the vehicle

_______6. Mounting shaft for the wheel and hub

_______7. Allows the control arm to move up and down

_______8. Supports vehicle load

_______9. Twists to support vehicle body weight and absorb shock

______10. Dampens the rebound and compression action of the coil spring to keep the tire on the road surface

A. Ball joint

B. Coil spring

C. Control arm

D. Control arm bushing

E. Shock absorber

F. Spindle

G. Stabilizer bar (sway bar)

H. Steering knuckle

I. Strut rod

J. Torsion bar

OBJECTIVE 10

State the functions of load-carrying and non-load-carrying ball joints.

1. Non-load-carrying ball joint: ______________________________

   ____

   ____

   ____

   ____

2. Load-carrying ball joint: ______________________________

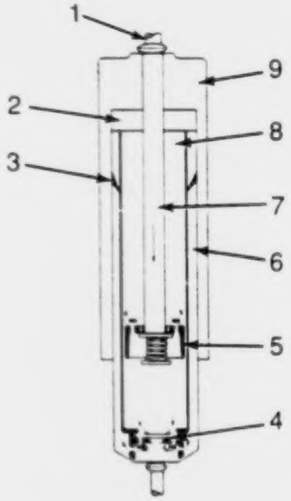
   ____

   ____

   ____

   ____

OBJECTIVE 11 **Label the parts of a shock absorber.** Write the correct letters in the blanks.



Courtesy of Volvo.

______1. A. Baffle ring

______2. B. Cover

______3. C. Dust cover

______4. D. Piston

______5. E. Piston rod

______6. F. Reservoir cylinder

______7. G. Upper attachment

______8. H. Valve

______9. I. Working cylinder

OBJECTIVE 12

Match the types of shock absorbers to their uses. Write the correct letters in the blanks.

______1. Used primarily when a firmer ride is desired; the gas is used to control fluid aeration

______2. Used when loads and ride heights vary; used as part of leveling suspension systems

______3. Used when the ride quality may need to be changed

______4. Used on vehicles that commonly carry heavy loads

A. Adjustable

B. Air

C. Gas-charged

D. Load-leveling type

OBJECTIVE 13

Describe the types of adjustable leveling suspension systems.

1. Automatic: ____

____

____

____

____

____

____

2. Manual: ____

____

____

____

____

____

____

OBJECTIVE 1

1. C
2. B
3. D
4. A
5. A
6. C
7. B
8. D
9. C
10. B
11. A
12. D
13. D
14. B
15. B

OBJECTIVE 2

Answers should include all of the following:

- Supports the weight of the front part of the vehicle
- Provides a smooth, comfortable ride by allowing the tire and wheel assemblies to move up and down with minimum movement of the car body
- Allows rapid cornering without extreme body roll
- Keeps the tires in firm contact with the road
- Works with the steering system to help keep the wheels in correct alignment

OBJECTIVE 3

Answers should include all of the following:

- Leaf springs
- Coil springs
- Torsion bar

OBJECTIVE 4

1. Independent suspension system having metal bars which twist to provide spring action
2. Independent suspension system with the front wheels connected to different I-beams and a coil spring mounted between each I-beam and the frame
3. Nonindependent suspension system with leaf springs
4. Independent suspension system with a lower control arm and strut assembly which includes a coil spring and a shock absorber
5. Independent suspension system with two sets of control arms and coil springs above or below the upper control arms; may have a strut rod

OBJECTIVE 5

1. D
2. A
3. E
4. F
5. B
6. C

OBJECTIVE 6

1. C
2. E
3. B
4. A
5. H
6. G
7. D
8. F

OBJECTIVE 7

1. A
2. I
3. H
4. G
5. C
6. F
7. J
8. K
9. D
10. B
11. E

OBJECTIVE 8

Longitudinal

1. I
2. B
3. F
4. C
5. E
6. G
7. H
8. A
9. D

Transverse

1. B
2. D
3. A
4. E
5. F
6. I
7. C
8. H
9. G
10. J
11. K
12. L

OBJECTIVE 9

1. H
2. A
3. G
4. C
5. I
6. F
7. D
8. B
9. J
10. E

OBJECTIVE 10

1. Stabilizes the steering knuckle position during movement of the control arm
2. Supports a portion of the vehicle's weight; transmits load from the control arm to the steering knuckle

OBJECTIVE 11

1. G
2. B
3. A
4. H
5. D
6. F
7. E
8. I
9. C

OBJECTIVE 12

1. C
2. B
3. A
4. D

OBJECTIVE 13

1. Sensor-activated system that uses air shocks, height or level sensors, and an electric compressor to maintain the curb height as passenger and luggage weights change
2. Operator-controlled, vacuum-operated or electric-compressor-operated system that uses air shocks to change the vehicle height as passenger and luggage weights change

OBJECTIVE SHEET

SERVICE REAR SUSPENSION SYSTEMS

IV

INTRODUCTION

The front and rear suspension systems work together to provide a comfortable ride and insure safe and accurate vehicle handling. Both must be checked by the steering and suspension technician before alignment. Damaged or worn rear suspension components cannot properly support the load of the vehicle and can cause the vehicle to track improperly. Problems in a vehicle's rear suspension may not be noticeable to the driver, so it is important that the steering and suspension technician have the skills necessary to inspect and service rear suspension systems.

PREREQUISITES

Before studying this unit, the student should have successfully completed Unit III, *Service Front Suspension Systems.*

UNIT OBJECTIVE

After completing this unit, the student should be able to diagnose rear suspension system problems and service common rear suspension systems. The student will demonstrate these competencies by completing the job sheets and the written test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to:

1. Select the definitions of terms associated with rear suspension systems.
2. State the purposes of the rear suspension system.
3. Describe types of rear suspension systems.
4. Label the parts of a multileaf spring assembly.
5. Label the parts of a coil spring assembly.
6. Match rear suspension parts to their purposes.
7. Label the parts of an automatic leveling control system.
8. Demonstrate the ability to:
    A. Inspect, remove, and replace nonindependent and semi-independent rear suspension system components. (Job Sheet 1)

B. Inspect, remove, and replace independent rear suspension system components. (Job Sheet 2)

C. Inspect and replace air shock absorbers. (Job Sheet 3)

SERVICE REAR SUSPENSION SYSTEMS

PREPARATION

- Review the unit and plan the presentation. Study the specific objectives to determine the order in which you will present the objectives.

- Review the teaching suggestions given in the Delivery and Application sections and plan classroom activities. Also note suggestions for media and supplemental materials.

- Plan your presentation to take advantage of student learning styles and to accommodate students with special needs.

- Many multiple-choice test questions (in the Pretests, Assignment Sheets, and Written Test) for this curriculum have been written in a style that is similar to the questions on the ASE certification test. Like ASE questions, the student should select the item that **BEST** answers the question. *The student should make no additional assumptions about a question other than those specifically given in the question.* A special effort has been made to provide good distracters for each question which will make the student think through the answer. It is suggested that the instructor review the answers to every test before reviewing the test with the students so that he or she is not caught off guard by such distracters.

- Obtain films, videotapes, and other media to supplement the instruction of this unit. See ordering information in the Suggested Resources section. Include in your selection media that demonstrate job sheet skills. Videotape your own demonstrations of job sheet procedures if you are unable to obtain suitable media.

- Obtain transparencies and competency profiles.

  NOTE: Transparencies and competency profiles for this book are available from the Curriculum and Instructional Materials Center, Oklahoma Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364.

- Prepare the classroom and shop. Display posters, charts, safety signs, etc., that emphasize suspension system service. Have articles, service manuals, specification guides, mock-ups, and other references about suspension system service available for student use.

- Discuss the purpose of pretesting with the students. Explain that they will be asked to complete a written pretest and that they will be required to demonstrate job sheet skills as part of the pretesting process.

- Provide the students with the equipment and materials necessary to complete the pretest. Administer the pretest.

- Use peer teaching to demonstrate job sheet procedures.

- Assess student competencies. Consider the pretest results as you prepare your presentation for each objective.

DELIVERY

Unit introduction

- Discuss the introduction to the unit. (See Objective Sheet.)

- Discuss the unit objective and then the specific objectives. Emphasize how accomplishing the specific objectives will lead to meeting the unit objective and how reaching the unit objective is vital to becoming an automotive steering and suspension technician. Relate the objective to your introduction and to material previously covered.

Objective 1 Select the definitions of terms associated with rear suspension systems.

- Show the students examples of as many of the terms listed in this objective as possible.

- Review the operation of an independent suspension and explain the similarities of and differences between front and rear independent suspension.

- Discuss the term *semi-independent rear suspension*. Explain to the students that this suspension system design has more in common with nonindependent rear suspension designs than with independent designs.

- Discuss the terms *rear-wheel torque* and *braking torque*. Explain how these forces cause *rear-end wrap-up*.

Objective 2 State the purposes of the rear suspension system.

- Discuss each of the purposes listed in this objective. Ask the students if they can think of examples for each of these purposes.

Objective 3 Describe types of rear suspension systems.

- Use Transparencies 1-4 to show the different types of rear suspension systems.
- Discuss each type presented and point out whether each is independent, semi-independent, or nonindependent.
- Discuss the advantages of each system and the types of vehicles that use them.
- Discuss alterations to rear suspension systems and the effects they have on ride, handling, steering geometry, and alignment. Include in your discussion alterations such as reversing or turning over leaf springs, installing spring hangers, using drop spindles, changing tires, using larger tire and wheel assemblies, and installing air shocks.
- Show examples of as many rear suspension systems as possible.

Objective 4 Label the parts of a multileaf spring assembly.

- Point out the parts of the leaf spring assembly. Use the information presented in Objective 6 to discuss the function of each part.
- Display both an assembled and a disassembled leaf spring and have the students identify the parts.
- Discuss the boxed material, "Rear-Wheel Wrap-Up." Have students refer to Objective 1, if necessary, to review *rear-wheel, torque*, and *braking torque*.

Objective 5 Label the parts of a coil spring assembly.

- Point out the parts of a coil spring assembly. Use the information presented in Objective 6 to discuss the function of each part.

- Explain the common variations in this type of assembly. For instance, not all vehicles use retainers.

Objective 6 Match rear suspension system parts to their purposes.

- Discuss the purpose of each part. Explain how each part accomplishes its purpose.

Objective 7 Label the parts of an automatic leveling control system.

- Point out each of the parts and discuss the function of each.

- List the types of vehicles that use automatic leveling systems.

- Explain how air shocks are used in these systems.

APPLICATION

Objective 8A Inspect, remove, and replace nonindependent and semi-independent rear suspension system components. (Job Sheet 1)

- Have the students review the descriptions of nonindependent and semi-independent rear suspension systems. Discuss the similarities and differences of the two.

- Explain to the students how nonindependent coil spring suspension designs vary. Also explain how leaf spring systems vary.

- Discuss the use of spring insulators and the importance of checking them to see that they are in good condition and are in the proper location.

- Show and tell students about the different aftermarket adjustment devices available. Explain that these devices allow spring heights to be varied in order to maintain proper vehicle height. Stress to the students that in most cases if vehicle height is not within specifications, the manufacturer advises replacing the necessary parts rather than using these devices.

- Discuss the importance of properly positioning jacks and jack stands. Have students locate jacking information in different service manuals. Discuss the possible results of incorrectly positioning jacks and jack stands.

- Explain that a hydraulic lift can be used when servicing rear suspensions, but great care must be used because using a lift poses other dangers. Caution students about using two different types of jack stands. For example, if the floor jack used to support the axle is raised too high, the vehicle could be forced off the lift or stands and fall forward.

- Discuss the equipment and materials used in Job Sheet 1. Review applicable safety rules and precautions and the guidelines given in the job sheet introduction with the students.

- Demonstrate Job Sheet 1. Have the students practice Job Sheet 1 until they are ready to take the practical test.

Objective 8B Inspect, remove, and replace independent rear suspension system components. (Job Sheet 2)

- Explain the inspection procedures for the more common types of independent rear suspensions. Discuss the differences between front and rear inspection procedures and explain that some of these differences are because the parts in the rear suspension can have functions different than those same parts in the front suspension.

- Have the students review the Guidelines and Procedures in Job Sheets 1, 2, and 5 in Unit 3, *Service Front Suspension Systems*. Point out the differences in procedures for rear suspensions.

- Discuss the equipment and materials used in Job Sheet 2. Review applicable safety rules and precautions and the guidelines given in the job sheet introduction with the students.

- Demonstrate Job Sheet 2. Have the students practice Job Sheet 2 until they are ready to take the practical test.

Objective 8C Inspect and replace air shock absorbers. (Job Sheet 3)

- Show the students an air shock absorber and explain its operation.

- Discuss the air shock absorbers used on vehicles with automatic and manual leveling systems and explain the different procedures for removing shocks from each system.

- Review the operation of the automatic level control with the students and discuss how such systems are tested. Discuss the differences between systems with electric compressors and those that are vacuum-operated.

- Discuss the electronic level control operation and how this type of system uses sensors and a computer.

- Discuss the equipment and materials used in Job Sheet 3. Review applicable safety rules and precautions and the guidelines given in the job sheet introduction with the students.

- Demonstrate Job Sheet 3. Have the students practice Job Sheet 3 until they are ready to take the practical test.

Unit summary activity

- Discuss Activity Sheet 1, Answer General Questions About Rear Suspension Systems. The purpose of the activity is to provide students with the opportunity to practice answering questions similar in content and style to those found on the actual ASE certification test.

- Have the students complete Activity Sheet 1.

EVALUATION

- Give the written test.

- Give the practical tests and evaluate the tests on the forms provided.

- Reteach and retest as required.

- Complete the appropriate section of the competency profiles.

SUGGESTED RESOURCES

Resources used in developing unit

- Bacon, Miles E. *Automotive Steering, Suspension, and Wheel Alignment.* New York: Gregg Division, McGraw-Hill Book Co., 1988.

- Bono, Saverio G. and William J. deKryger. *Auto Technology.* Albany, New York: Delmar Publishers, Inc., 1990.

- *Brakes, Steering and Suspension, 1980-87.* Radnor, Pennsylvania: Chilton Book Co., 1988.

- Coghlan, David A. *Automotive Chassis Systems: Steering, Suspension, Alignment, and Brakes.* 2nd ed. Boston: Breton Publishers, A Division of Wadsworth, Inc., 1985.

- Crouse, William H., and Donald L. Anglin. *Automotive Brakes, Suspension, and Steering.* New York: Gregg Division, McGraw-Hill Book Co., 1983.

- Crouse, William H., and Donald L. Anglin. *Automotive Mechanics.* 9th ed. New York: Gregg Division, McGraw-Hill Book Co., 1985.

- Duffy, James E. *Modern Automotive Mechanics.* South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1985.

- Ellinger, Herbert E., and Richard B. Hathaway. *Automotive Suspension and Steering Theory and Service.* Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1989.

- *Ford 1987 Car Shop Manual, Body/Chassis/Electrical: Lincoln Town Car, Ford Crown Victoria, Mercury Grand Marquis.* Dearborn, Michigan: Ford Parts and Service Division, Training and Publications Dept., 1986.

- *Ford 1988 Car Shop Manual, Vol. C, Body/Chassis/Electrical: Tempo/Topaz, Escort.* Dearborn, Michigan: Ford Parts and Service Division, Training and Publications Dept., 1987.

- *Ford 1988 Truck Shop Manual: Aerostar.* Dearborn, Michigan: Ford Parts and Service Division, Training and Publications Dept., 1987.

- *Ford 1988 Truck Shop Manual, Vol. A, Light Truck Body/Chassis/Electrical: Bronco, Econoline, F150-F350, F-Series Super Duty.* Dearborn, Michigan: Ford Parts and Service Division, Training and Publications Dept., 1987.

- *Hunter 4-Wheel Alignment Seminar.* Bridgeton, Missouri: Hunter Engineering Co., 1981.

- *Mitchell Automechanics.* Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1991.

- *Mitchell Chassis Service & Repair Domestic Cars: 1985 Supplement.* San Diego, California: Mitchell International, Inc.

- *Moog Front-End Service Manual.* St. Louis, Missouri: Moog Automotive Inc., 1982.

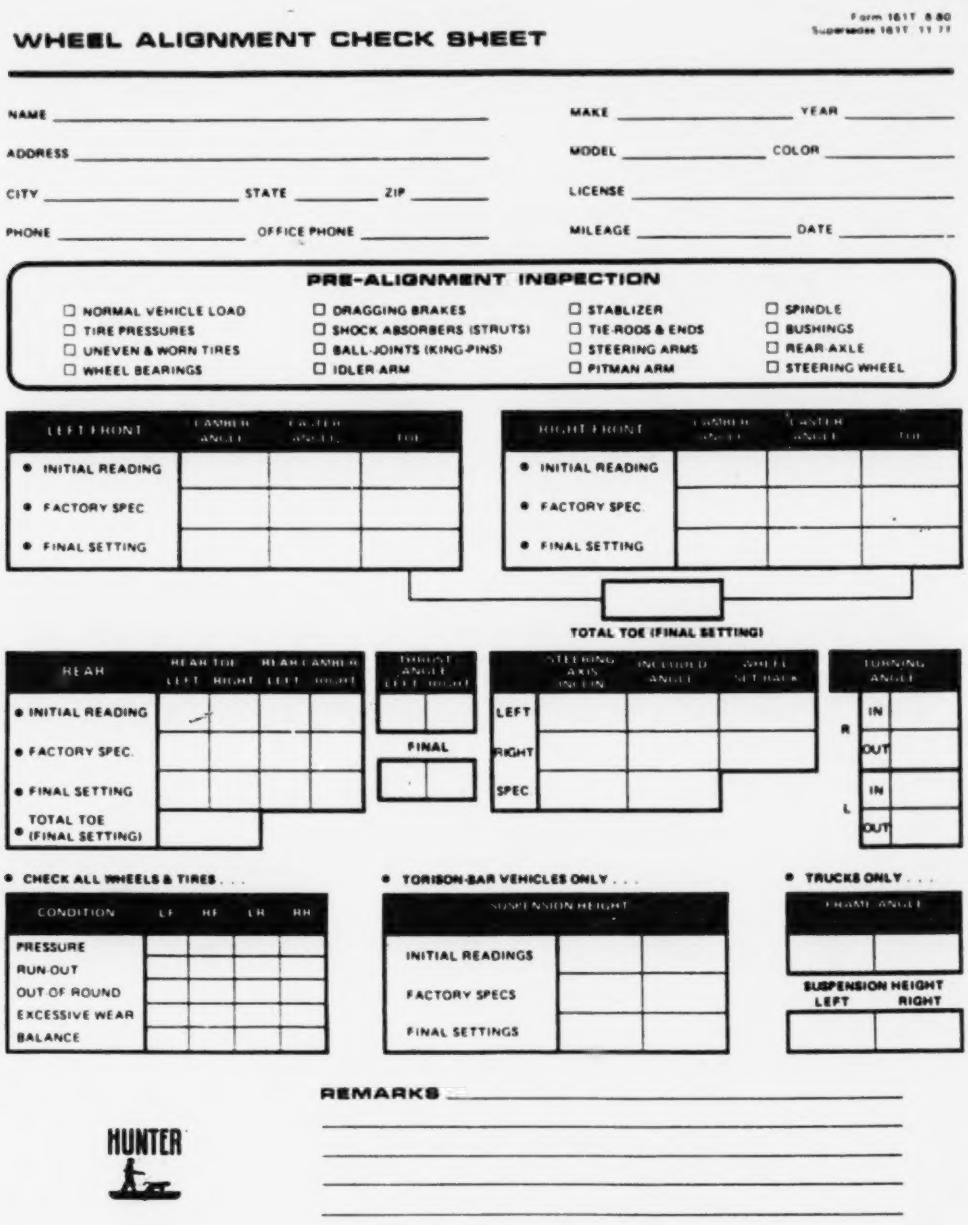
- *1980 Chevrolet Corvette Shop Manual.* Detroit, Michigan: General Motors Corp., Chevrolet Motor Division, 1979.

- *1990 Chevrolet Light Duty Truck Service Manual: C-K Truck Models.* Warren, Michigan: General Motors Corp., Chevrolet Motor Division, 1989.

- *Steering, Suspension, Wheel Alignment and Balance: Student Reference Book.* Centerline, Michigan: Chrysler Corp. Service and Parts Operations, Training Program Development Dept., n.d.

- Stockel, Martin W., and Martin T. Stockel. *Auto Mechanics Fundamentals.* South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1985.

- Stockel, Martin W., and Martin T. Stockel. *Auto Service and Repair.* South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1984.



Form 1617 8-80
Supersedes 1617 11-77

WHEEL ALIGNMENT CHECK SHEET

NAME ______________________
ADDRESS ______________________
CITY ____________ STATE ________ ZIP ________
PHONE ____________ OFFICE PHONE ____________
MAKE ____________ YEAR ________
MODEL ____________ COLOR ________
LICENSE ______________________
MILEAGE ____________ DATE ________

PRE-ALIGNMENT INSPECTION

☐ NORMAL VEHICLE LOAD
☐ TIRE PRESSURES
☐ UNEVEN & WORN TIRES
☐ WHEEL BEARINGS
☐ DRAGGING BRAKES
☐ SHOCK ABSORBERS (STRUTS)
☐ BALL-JOINTS (KING-PINS)
☐ IDLER ARM
☐ STABLIZER
☐ TIE-RODS & ENDS
☐ STEERING ARMS
☐ PITMAN ARM
☐ SPINDLE
☐ BUSHINGS
☐ REAR AXLE
☐ STEERING WHEEL

LEFT FRONT	CAMBER ANGLE	CASTER ANGLE	TOE
● INITIAL READING			
● FACTORY SPEC			
● FINAL SETTING			

RIGHT FRONT	CAMBER ANGLE	CASTER ANGLE	TOE
● INITIAL READING			
● FACTORY SPEC.			
● FINAL SETTING			

TOTAL TOE (FINAL SETTING) ________

REAR	REAR TOE		REAR CAMBER	
	LEFT	RIGHT	LEFT	RIGHT
● INITIAL READING				
● FACTORY SPEC.				
● FINAL SETTING				
● TOTAL TOE (FINAL SETTING)				

THRUST ANGLE	
LEFT	RIGHT
FINAL	

	STEERING AXIS INCLIN	INCLUDED ANGLE	WHEEL SET BACK
LEFT			
RIGHT			
SPEC.			

TURNING ANGLE		
R	IN	
	OUT	
L	IN	
	OUT	

● CHECK ALL WHEELS & TIRES . . .

CONDITION	LF	RF	LR	RR
PRESSURE				
RUN-OUT				
OUT-OF-ROUND				
EXCESSIVE WEAR				
BALANCE				

● TORISON-BAR VEHICLES ONLY . . .

SUSPENSION HEIGHT		
INITIAL READINGS		
FACTORY SPECS		
FINAL SETTINGS		

● TRUCKS ONLY . . .

FRAME ANGLE	

SUSPENSION HEIGHT	
LEFT	RIGHT

REMARKS ______________________

HUNTER

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PRETEST ANSWERS

SERVICE REAR SUSPENSION SYSTEMS IV

EVALUATOR NOTE

Use the following answer key to check student answers to pretest questions. To determine the students' individual study requirements from the pretest results, use the following table which shows the correlation between the objectives and pretest questions. Then counsel students individually on pretest results and study requirements.

TABLE

Correlation between objectives and pretest questions:

Objective	Question
1	1, 13
2	2, 12
3	3, 15
4	18, 19, 20, 21
5	6, 7, 8, 9
6	4, 5, 23
7	27, 28, 29
8A	10, 16, 26, 30
8B	11, 17, 25
8C	14, 22, 24

ANSWER KEY

1. B
2. C
3. A
4. A
5. C
6. A
7. B
8. B
9. C
10. C
11. A
12. D
13. D
14. B
15. C
16. C
17. C
18. B
19. A
20. A
21. B
22. D
23. B
24. A
25. D
26. B
27. C
28. C
29. B
30. A

SERVICE REAR SUSPENSION SYSTEMS

NAME ______________________ SCORE ______

DIRECTIONS

Read the following questions and problems. Write the letter of the correct answer in the blank.

______1. Which of the following statements best defines *independent rear suspension*?

A. System in which the suspension components of both wheels attach to the same straight axle; movement of one wheel affects the other wheel
B. System that allows the suspension components on one side of the vehicle to move separately of the components on the other side; movement of one wheel does not directly affect the other wheel
C. System in which the suspension components of both wheels attach to the same axle or frame crossmember and the components on one side of the vehicle move separately of components on the other side; movement of one wheel only slightly affects the other wheel
D. System in which the suspension components attach to the control arms rather than to the rear axle; movement of one wheel only slightly affects the other wheel

______2. Technicians A and B are discussing the purposes of the rear suspension system. Technician A says that one purpose is to keep the rear wheels in the correct position. Technician B says that one purpose is to support the weight of the rear part of the vehicle. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______3. Which of the following statements best describes a *transverse leaf spring suspension*?

A. Independent suspension system with a leaf spring mounted transversely to the frame parallel to the wheel axle; each end of the spring acts as a single spring for that particular side of the vehicle
B. Nonindependent suspension system with the leaf spring mounted parallel to the frame transverse to the axle; the ends of the spring work together to act as one single spring for the rear of the vehicle
C. Independent suspension system with two leaf springs, each mounted longitudinally to the frame and axle; the springs act separately of one another
D. None of the above

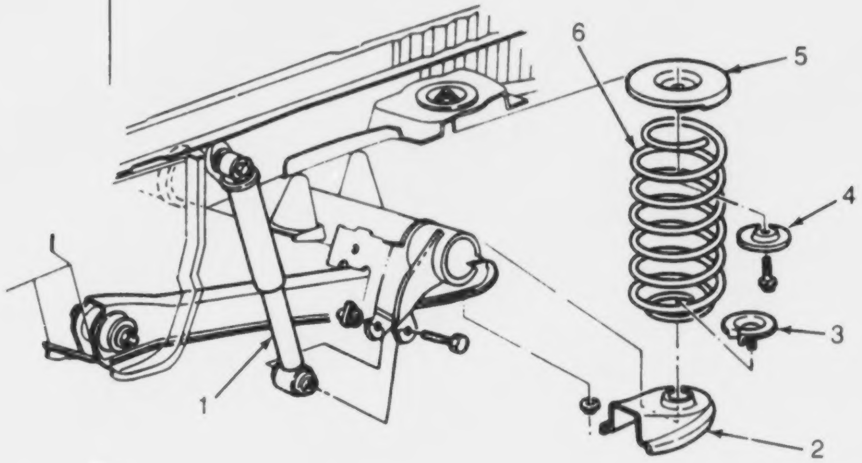
______4. Technician A says the purpose of the track bar is to prevent the car body from moving side to side. Technician B says the purpose of the track bar is to control front-to-rear movement of the rear axle. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______5. The purpose of a *shackle* is to:

A. Support the vehicle load
B. Hold the leaf springs together
C. Allow the leaf spring to lengthen or shorten and reduce shock transferred to the vehicle body
D. Absorb shock and reduce noise at the component or part connections

For items 6-9, refer to the illustration below:



Used with permission of Ford Motor Co.

_______6. Which part is the *upper retainer*?

A. 4
B. 5
C. 6
D. None of the above

_______7. Which part is the *lower mount and/or insulator*?

A. 6
B. 2
C. 1
D. 4

_______8. The part labeled 3 is the:

A. Lower mount and/or insulator
B. Lower retainer
C. Upper retainer
D. Shock absorber mount

______9. The part labeled 5 is the:

A. Shock absorber mount
B. Upper retainer
C. Upper mount and/or insulator
D. None of the above

______10. Technicians A and B are discussing leaf springs. Technician A says if the leaf springs have separated, the bushing in the spring eye probably needs to be replaced. Technician B says shifted leaf springs can indicate the center bolt is broken. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______11. Which of the following statements about independent rear suspension system components is **not** true?

A. Rear suspension systems can have control arms welded to the rear axle
B. Rear suspension systems can have four control arms
C. Rear suspension systems can have transversely mounted leaf springs
D. Rear suspension systems can have two control arms

______12. Which of the following is a purpose of the rear suspension system?

A. Maintains the correct vehicle height at the rear of the vehicle
B. Keeps the rear wheels in the correct position
C. Controls rear-end wrap-up
D. All of the above

_____13. Which of the following statements best defines *braking torque*?

A. Reactive force occurring when the vehicle is in motion in which the suspension components try to move in the direction opposite that of the vehicle
B. Reactive force occurring when the vehicle begins a forward movement in which the axle housing tries to rotate in the direction opposite that of wheel rotation
C. Condition in which uncontrolled rear-wheel and driving torque force the rear of the vehicle upward
D. Reactive force during vehicle braking in which the axle housing tries to rotate in the direction of the wheel rotation before the brakes were applied

_____14. Technicians A and B are discussing air shock absorbers. Technician A says the automatic level control height compressors must be disconnected before removing the air shocks. Technician B says air shocks can be used on vehicles not equipped with automatic level control. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____15. *Solid axle suspension system with the leaf springs mounted parallel to the frame on each side of the vehicle* is the description of what rear suspension system?

A. MacPherson strut type
B. Transverse leaf spring
C. Leaf spring
D. None of the above

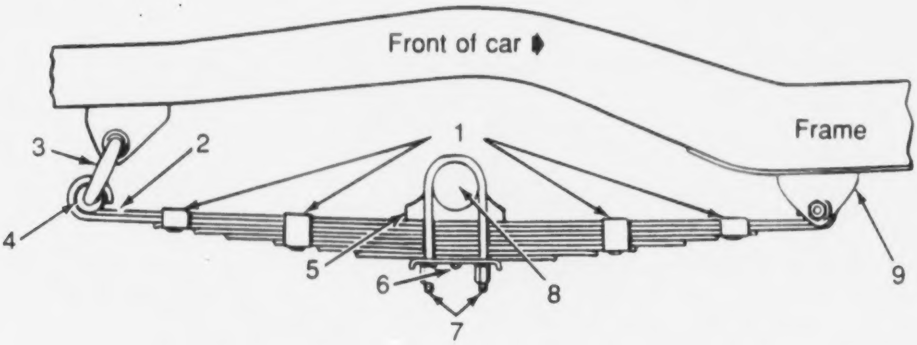
_____16. Technicians A and B are discussing nonindependent suspension service. Technician A says the track bar should be replaced if it is bent or damaged. Technician B says some vehicles with nonindependent suspensions do not have track bars. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____17. Technician A says independent rear suspension systems have more parts than semi-independent or nonindependent systems. Technician B says control arm replacement procedures are the same as for the front suspension. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

For items 18-21, refer to the illustration below:



Reprinted with permission of the MacMillan/Glencoe Division of McGraw-Hill School Publishing Co., from *Automotive Brakes, Suspension, and Steering*, by William H. Crouse and Donald L. Anglin, 1983.

_____18. Which part is the *spring eye*?

A. 1
B. 4
C. 3
D. 9

_____19. The parts labeled 1 are:

A. Rebound clips
B. Insulators
C. Rebound bushings
D. Spring shackles

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______20. Which part is the *spring center bolt*?

A. 6
B. 7
C. 5
D. None of the above

______21. The part labeled 9 is the:

A. U-bolt
B. Spring hanger
C. Frame
D. Axle

______22. Which of the following statements is a guideline that should be followed when inspecting and replacing air shock absorbers?

A. Check for air leakage by applying a soap and water solution to air lines, to fittings, and around air valves
B. Clean the connectors and the surrounding areas before disconnecting any air line
C. Disconnect the automatic level control height sensor before allowing the suspension and rear axle to hang free
D. All of the above

______23. The purpose of rebound clips is to:

A. Reduce friction between the spring leaves and reduce noise when the spring flexes
B. Hold the spring leaves together
C. Allow the leaf spring to lengthen or shorten and reduce the shock transferred to the vehicle body
D. Absorb shock and reduce noise at the component or part connections

_____24. Which of the following statements about air shock absorbers is **not** correct?

- A. Air shocks have special air chambers with a fixed amount of air in them
- B. Vehicles can have factory-equipped air shock absorbers
- C. Air shocks are used with manual leveling suspension systems
- D. Air shocks have air valves

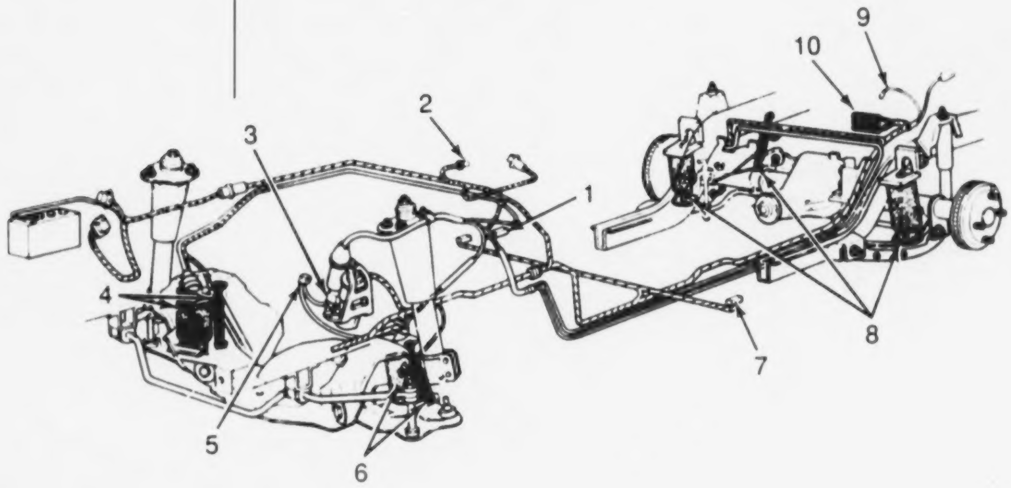
_____25. Technicians A and B are discussing independent rear suspension systems. Technician A says these systems have the same basic components. Technician B says service for different rear independent systems is the same. Who is correct?

- A. Technician A
- B. Technician B
- C. Both A and B
- D. Neither A nor B

_____26. Which of the following statements about nonindependent and semi-independent coil spring suspension systems is **not** correct?

- A. Coil springs can be mounted on the control arms
- B. Coil springs can be mounted on the driver's seat in the vehicle body
- C. Coil springs can be mounted on the rear axle housing
- D. Coil springs are **not** mounted on the differential housing

For items 27-29 refer to the illustration below:



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_____27. Which part is the *air compressor vent solenoid*?

A. 5
B. 4
C. 3
D. 2

_____28. The part labeled 8 is the:

A. Hydraulic brake line
B. Air line
C. Rear air spring and height sensor
D. None of the above

_____29. Which part is the *brake sensor*?

A. 5
B. 1
C. 3
D. 2

_____30. Which of the following statements about a leaf spring rear suspension is true?

A. Leaf springs can be mounted transversely
B. Shock absorbers are not used
C. All leaf springs have a shackle and three spring eyes
D. Leaf springs are used only on trucks

SERVICE REAR SUSPENSION SYSTEMS

OBJECTIVE 1

Select the definitions of terms associated with rear suspension systems.

braking torque — Reactive force during vehicle braking in which the axle housing tries to rotate in the direction of the wheel rotation before the brakes were applied

differential — Assembly that drives both rear axles but allows the wheels to rotate at different speeds during turns

independent rear suspension — System that allows the suspension components on one side of the vehicle to move separately from the components on the other side; movement of one wheel does not directly affect the other wheel

monoleaf spring — Tapered leaf spring consisting of a single leaf made of metal or fiberglass

multileaf spring — Leaf spring made of layers of leaves of different lengths

nonindependent (solid-axle) rear suspension — System in which the suspension components of both wheels attach to the same straight axle housing; movement of one wheel affects the other wheel

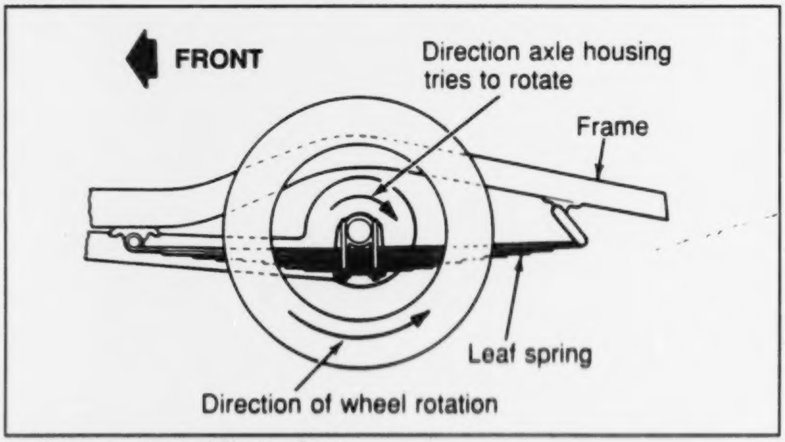
NOTE: This type of suspension system is sometimes called a *conventional* suspension.

rear-end wrap-up — Condition resulting from the differential turning the axle while friction between the tires and the ground prevents the wheels from turning

rear-wheel torque — Reactive force occurring when the vehicle begins a forward movement in which the axle housing tries to rotate in the direction opposite that of wheel rotation (See Figure 1 on the following page.)

EXAMPLE:

FIGURE 1


FRONT
Direction axle housing tries to rotate
Frame
Leaf spring
Direction of wheel rotation

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semi-independent rear suspension — System in which the suspension components of both control arms are connected to the same axle or frame crossmember and in which the suspension components on one side of the vehicle move separately from the components on the other side; movement of one wheel only slightly affects the other wheel (Figure 2)

NOTE: As shown in Figure 2, the frame crossmember can twist and act as a stabilizer bar in this type of system.

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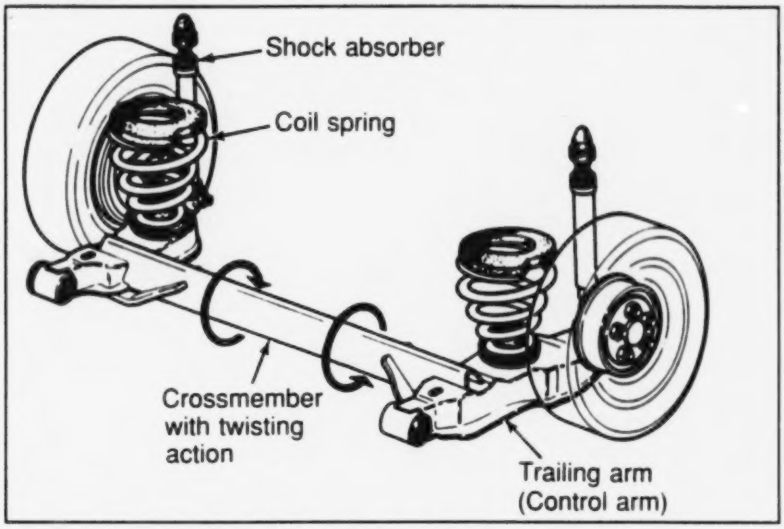
EXAMPLE:

FIGURE 2


Shock absorber
Coil spring
Crossmember with twisting action
Trailing arm (Control arm)

Copyright © General Motors Corp. Used with permission.

trailing-arm suspension — Semi-independent or nonindependent rear suspension system in which the control arms extend rearward from the body attachment point (Figure 2)

NOTE: The control arms are usually attached either to the body or a frame crossmember and to the axle. In this suspension system, the control arms are sometimes called *trailing arms.*

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OBJECTIVE 2

State the purposes of the rear suspension system.

- Supports the weight of the rear part of the vehicle

- Provides a smooth, comfortable ride by allowing the wheels to move up and down with minimum movement of the car body

- Keeps the tires in firm contact with the road

  NOTE: The rear suspension system allows the tires to maintain road contact when traveling over high and low points of the road surface, such as when they strike bumps or holes in the road.

- Maintains the correct vehicle height at the rear of the vehicle

  NOTE: If the rear of the vehicle is above or below the specified height, alignment can be affected.

- Keeps the rear wheels in the correct position

  NOTE: The rear wheels of a vehicle should roll straight with the vehicle and should be parallel to the front wheels. Rear suspension components affect the positions of the rear wheels.

- Controls rear-end wrap-up

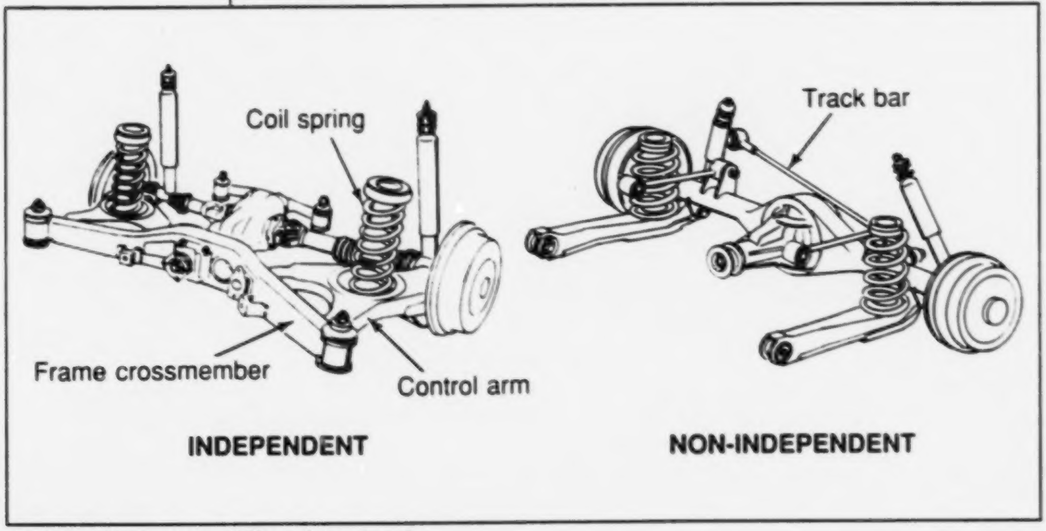
  NOTE: Rear-end wrap-up greatly affects the stability of the vehicle and can cause vehicle damage such as a broken drive shaft or damaged transmission extension housing on rear-wheel drive vehicles.

OBJECTIVE 3 **Describe types of rear suspension systems.**

Coil spring — Independent, semi-independent, or nonindependent suspension system which uses coil springs on each side of the vehicle between the frame or body and the axle housing or control arms (Figure 3)

EXAMPLE:

FIGURE 3


Coil spring
Track bar
Frame crossmember
Control arm
INDEPENDENT
NON-INDEPENDENT

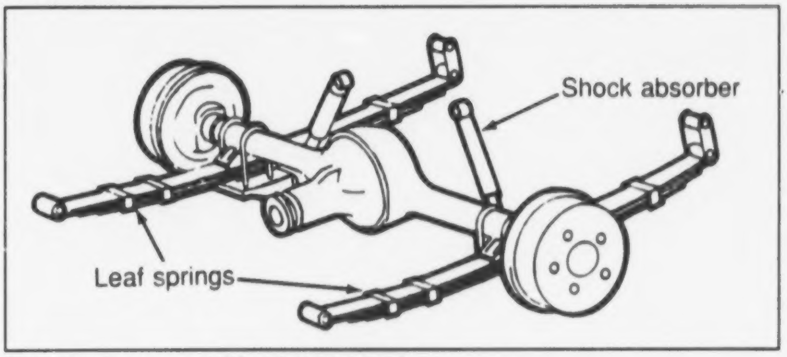
Adapted with permission of Moog Automotive, Inc.

Leaf spring — Solid axle suspension system with leaf springs mounted parallel to the frame on each side of the vehicle (Figure 4)

NOTE: Most systems use multileaf springs, but a few use monoleaf springs. Some leaf spring systems, particularly those commonly used on heavy-duty truck suspensions, incorporate an auxiliary spring.

EXAMPLE:

FIGURE 4



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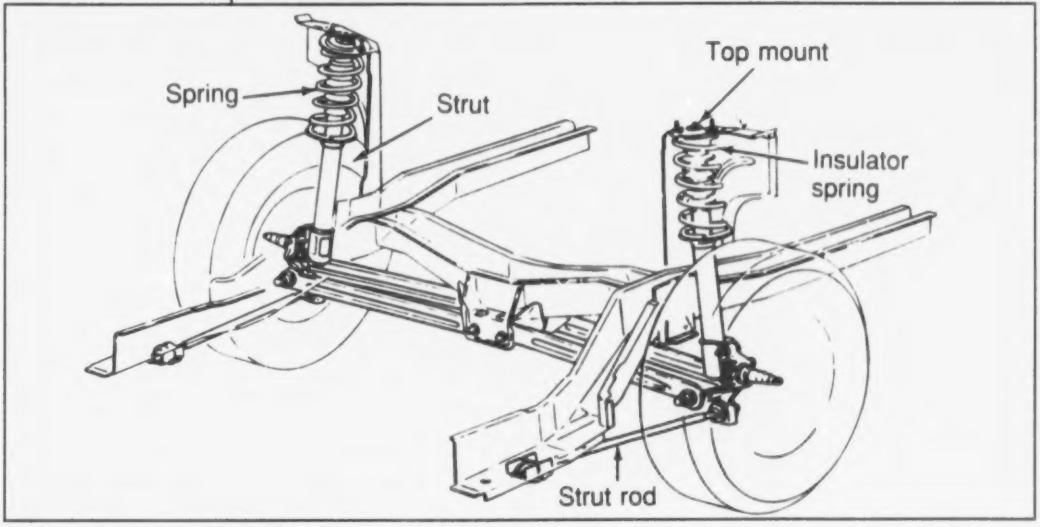
MacPherson strut — Independent or semi-independent suspension system with a strut assembly on each side of the vehicle; strut assemblies are mounted between the spindle and the body or frame (Figure 5)

NOTE: Two types of MacPherson struts, modified and full, are available. The modified MacPherson, with a separate strut piece, is used in domestic cars, while the full MacPherson strut is preferred by import designers.

EXAMPLE:

FIGURE 5



Used with permission of Ford Motor Co.

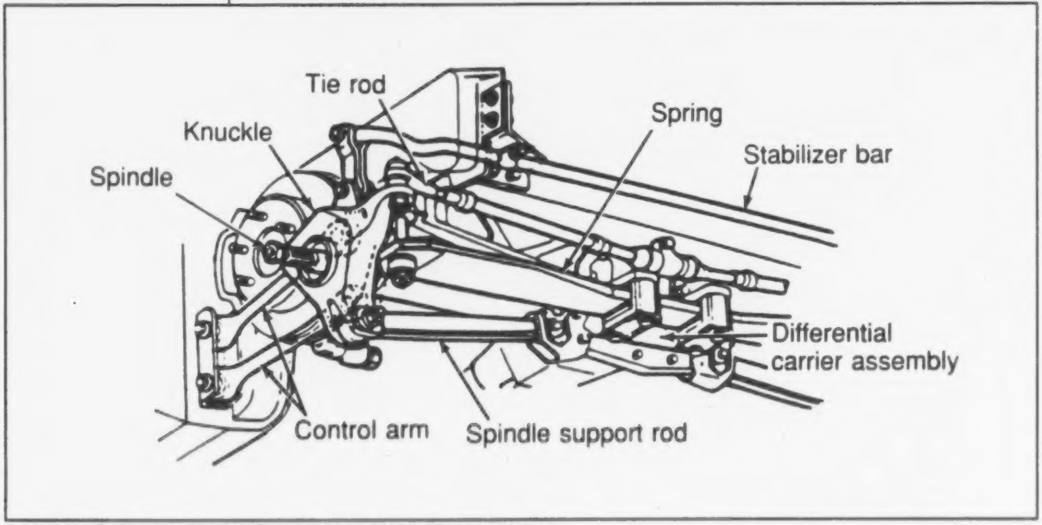
Transverse leaf spring — Independent suspension system with a leaf spring mounted transversely to the frame parallel to the wheel axle; each end of the spring acts as a single spring for that particular side of the vehicle (Figure 6)

CAUTION

Some transverse leaf springs are not made of metal and may be damaged by heat or sharp blows.

EXAMPLE:

FIGURE 6


Tie rod
Spring
Knuckle
Stabilizer bar
Spindle
Differential carrier assembly
Control arm
Spindle support rod

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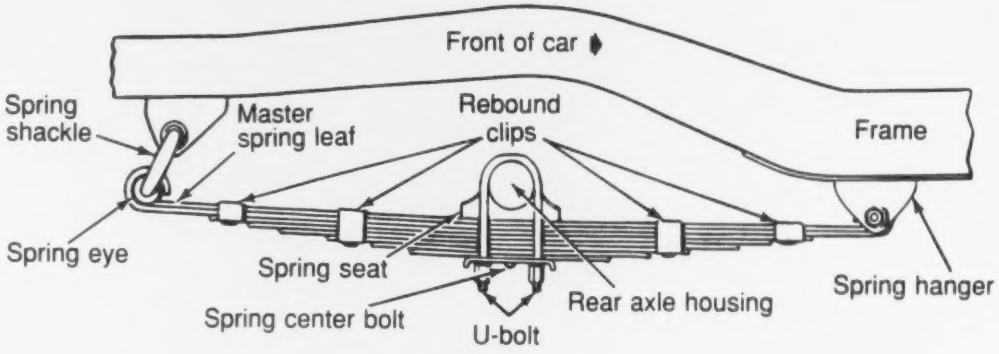
OBJECTIVE 4 **Label the parts of a multileaf spring assembly.**

FIGURE 7

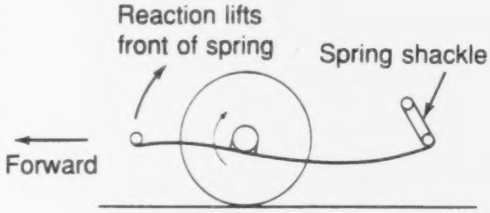

Front of car
Spring shackle
Master spring leaf
Rebound clips
Frame
Spring eye
Spring seat
Spring center bolt
U-bolt
Rear axle housing
Spring hanger

Reprinted with permission of the Macmillan/Glencoe Division of McGraw-Hill School Publishing Co., from *Automotive Brakes, Suspension, and Steering*, by William H. Crouse and Donald L. Anglin, 1983.

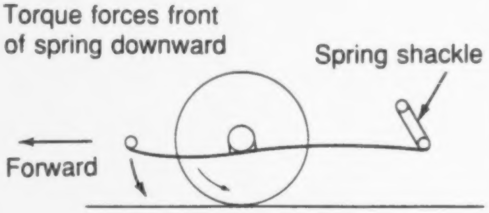
REAR-END WRAP-UP

Leaf springs are designed to support the vehicle load and stabilize the rear of the vehicle. The leaf spring is attached to the frame at the front with a spring hanger and spring seat. Each end of the spring has a spring eye. A shackle connects the frame to the rear spring eye. As a vehicle travels over bumps and dips, these connections allow the springs to flex as they move.

The leaf spring is also designed to control rear-end wrap-up. This is a condition which exists when rear-wheel torque or braking torque is uncontrolled and the rear of the vehicle is forced upward by reactive forces. The illustrations below show how leaf springs control braking torque and driving torque.


Reaction lifts front of spring
Spring shackle
Forward

Direction of driving torque on the axle housing

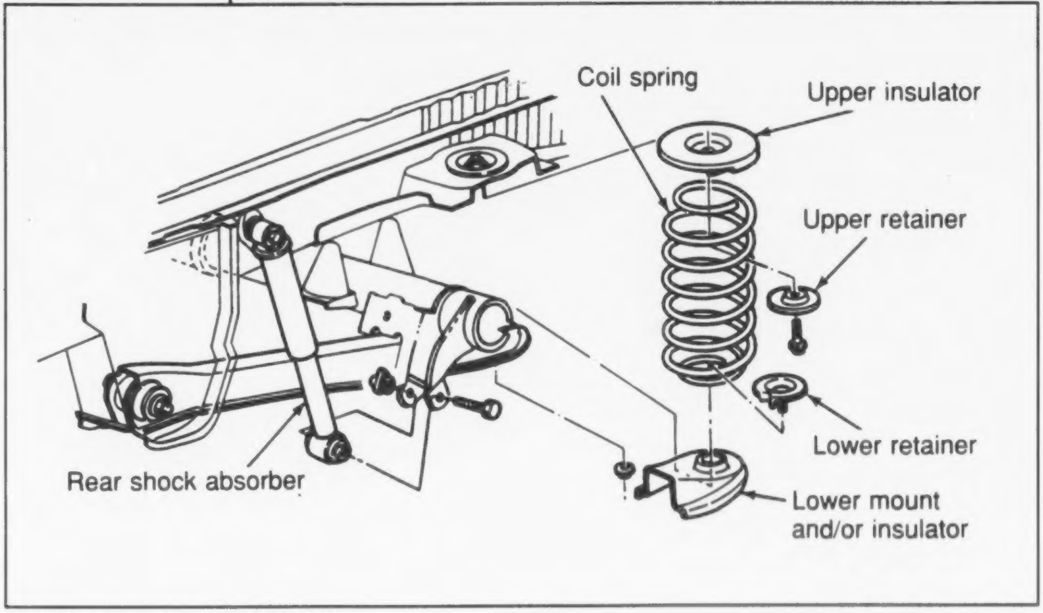

Torque forces front of spring downward
Spring shackle
Forward

Direction of braking torque

Herbert E. Ellinger/Richard B. Hathaway, *Automotive Suspension and Steering: Theory and Service*, © 1989. Reprinted by permission of Prentice Hall, Englewood Cliffs, N.J.

OBJECTIVE 5 **Label the parts of a coil spring assembly.**

FIGURE 8


Coil spring
Upper insulator
Upper retainer
Lower retainer
Lower mount and/or insulator
Rear shock absorber

Used with permission of Ford Motor Co.

NOTE: Coil spring assemblies are sometimes equipped with air bags which add support or load-carrying capacity to the assembly.

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OBJECTIVE 6

Match rear suspension system parts to their purposes.

air shocks — Support the vehicle load in a system that can be adjusted to compensate for changes in the vehicle load

bushings — Absorb shock and reduce noise at the component or part connections

coil springs — Support the vehicle load by using metal or metal alloy coils that compress or expand as necessary

control arms — Control front-to-rear movement of the rear axle to keep the axle properly aligned and control rear-end wrap-up

NOTE: When control arms are located on a rear suspension system, some manufacturers may refer to them as ***trailing arms***. Control arms are used with coil spring or MacPherson strut suspension systems.

insulators — Reduce friction between the spring leaves and reduce noise when the spring flexes

leaf springs — Support the vehicle load and control rear-wheel torque

rebound clips — Hold the spring leaves together

shackles — Allow the leaf spring to lengthen or shorten and reduce shock transferred to the vehicle body

stabilizer bars (sway bars) — Prevent the car body from leaning excessively in sharp turns

NOTE: Stabilizer bars can be used with all types of suspension systems.

strut rods — Control the front-to-rear movement of the rear axle

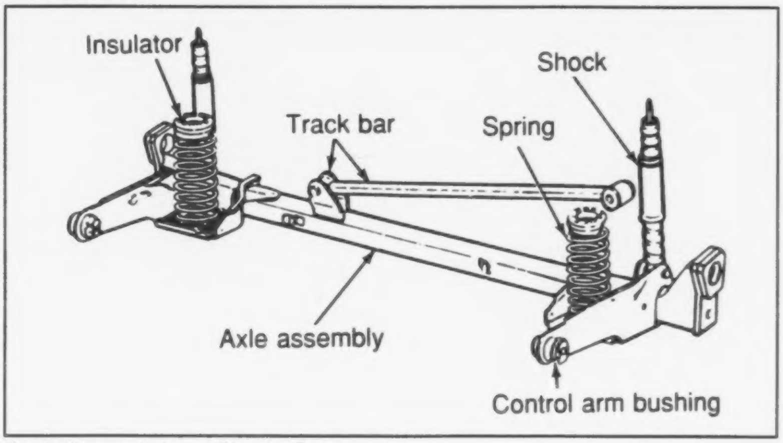
NOTE: One end of a strut rod is attached to the frame, and the other end is connected to either the axle, one of the control arms, or the other component in order to keep the axle from shifting its position. Strut rods can be used with any type of rear suspension system.

track bars (panhard rods) — Prevent the car body from moving side-to-side

NOTE: Track bars are used with nonindependent and semi-independent suspension systems. One end of the track bar is connected to the vehicle frame and the other end is connected to the rear axle housing, as shown in Figure 9.

EXAMPLE:

FIGURE 9


Insulator
Shock
Track bar
Spring
Axle assembly
Control arm bushing

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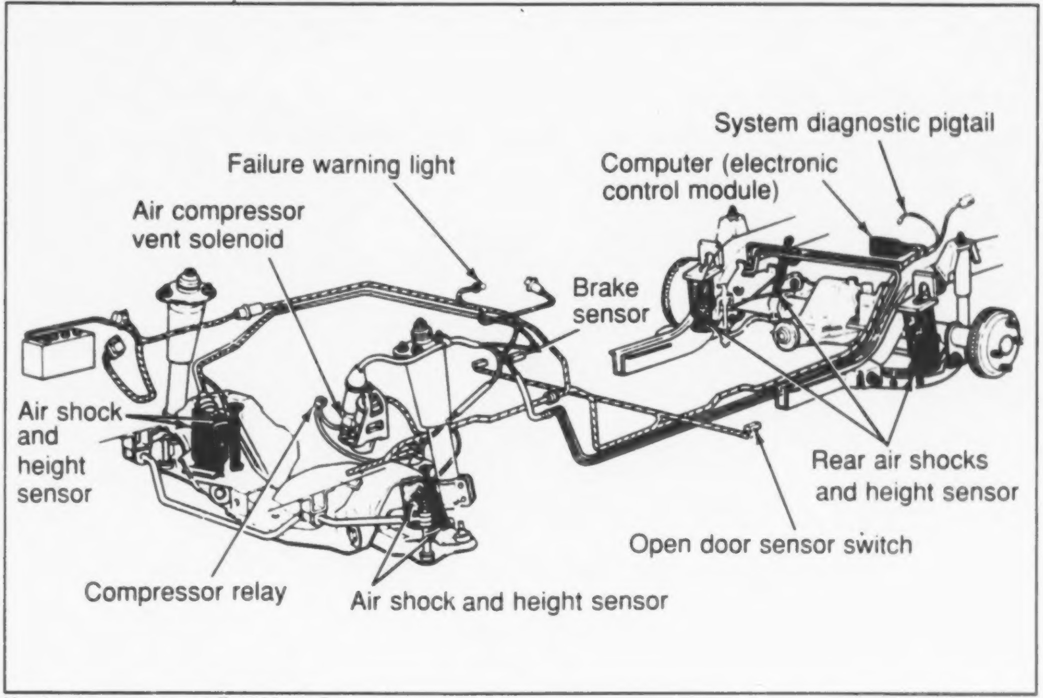
OBJECTIVE 7 **Label the parts of an automatic leveling control system.**

FIGURE 10


System diagnostic pigtail
Failure warning light
Computer (electronic control module)
Air compressor vent solenoid
Brake sensor
Air shock and height sensor
Rear air shocks and height sensor
Open door sensor switch
Compressor relay
Air shock and height sensor

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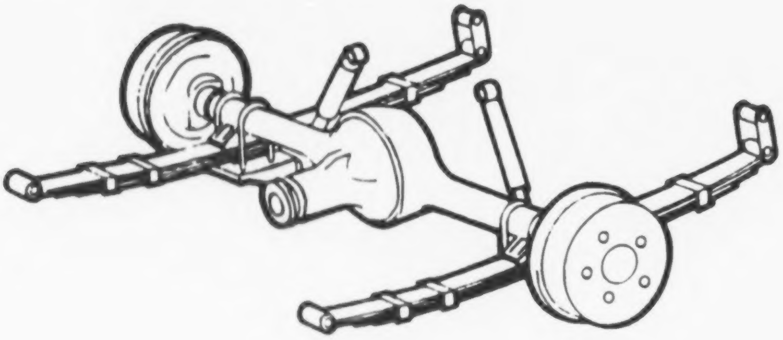
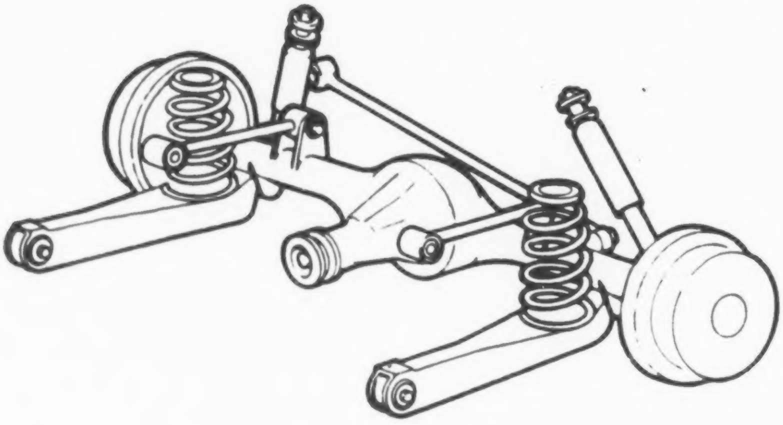
Types of Rear Suspension

Non-Independent with Leaf Springs



Non-Independent with Coil Springs



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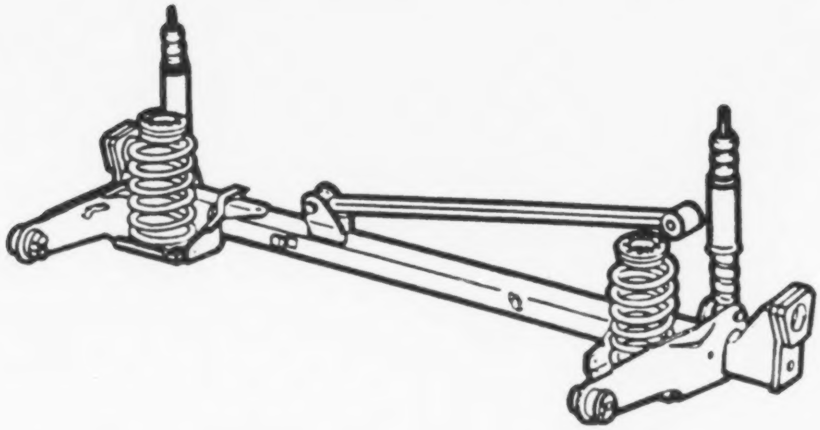
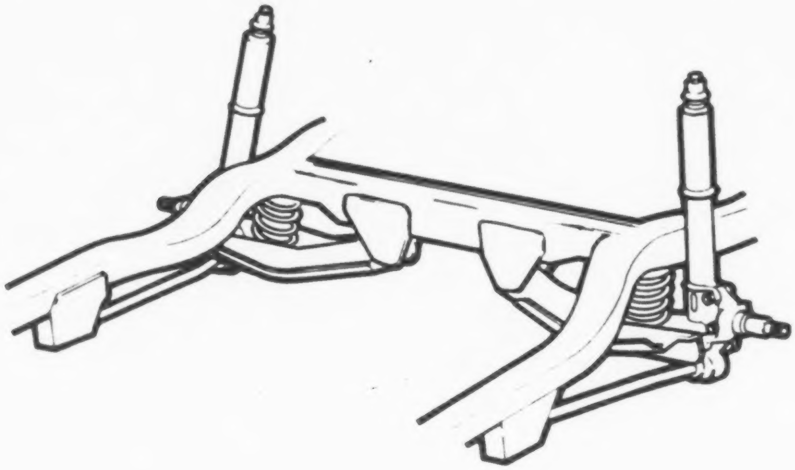
Types of Rear Suspension

Straight, Non-Drive Rear Axle



Independent Rear with Modified MacPherson Strut and Adjustable Tie Bar



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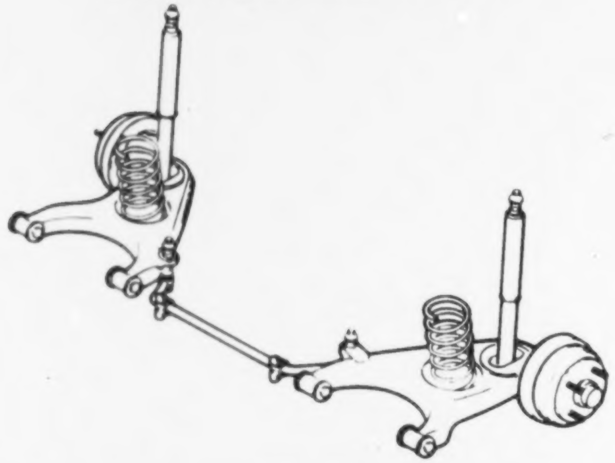
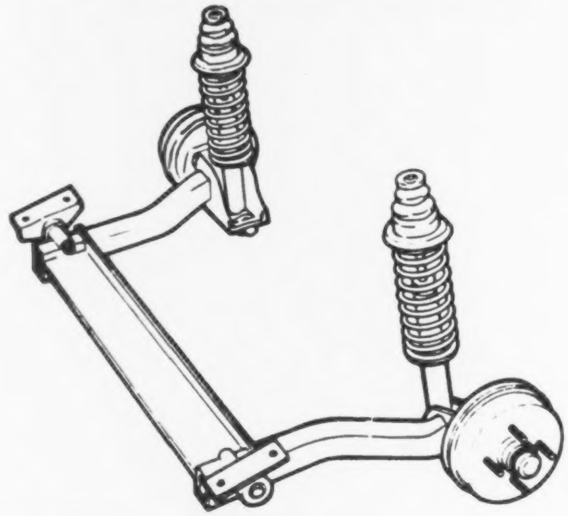
Types of Rear Suspension

Independent with Coil Springs and Adjustable Toe



Independent Rear with MacPherson Struts— Front Wheel Drive



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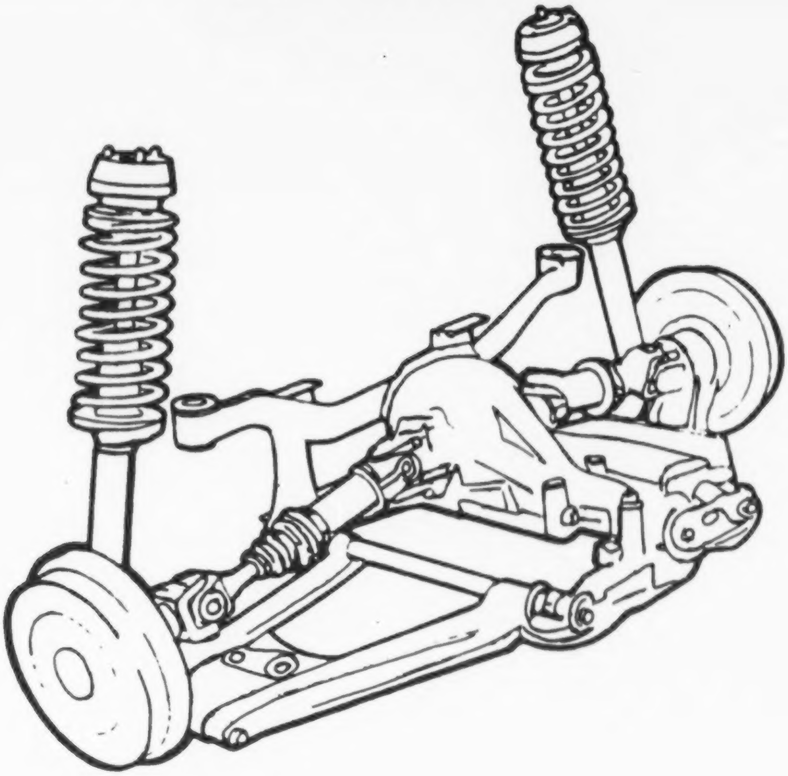
Types of Rear Suspension

Independent Rear with MacPherson Struts—Rear Wheel Drive



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ACTIVITY SHEET 1

SERVICE REAR SUSPENSION SYSTEMS IV

ANSWER GENERAL QUESTIONS ABOUT REAR SUSPENSION SYSTEMS

NAME ______________________________ SCORE ________

INTRODUCTION

To become certified as a steering and suspension specialist, you must pass a test on the steering and suspension systems compiled by the National Institute for Automotive Service Excellence. The certification test covers all aspects of the vehicle's steering and suspension systems. This activity sheet covers only rear suspension systems, but it contains realistic questions similar in content and style to those found on the actual ASE certification test.

DIRECTIONS

Read each of the following study questions twice. The second time, you may notice a key word you overlooked the first time. Every word in a question is important and may provide a clue to the right answer. Select the answer that is **most** correct and write its letter in the answer blank.

After you have completed this activity sheet, get together with a group of your classmates and use the answer key to check your answers. Discuss the questions and their correct answers, paying particular attention to those that were answered incorrectly. Review any information you do not understand.

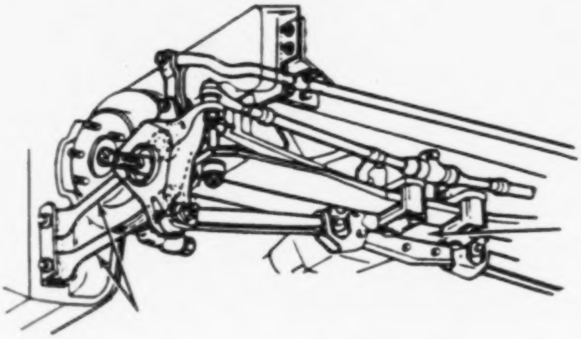
______1. Technicians A and B are discussing independent rear suspension service. Technician A says leaf springs must be thoroughly inspected. Technician B says leaf springs are not used on independent rear suspensions. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______2. Technicians A and B are discussing transverse leaf springs. Technician A says rear suspension systems having transverse leaf springs are independent systems. Technician B says these systems are nonindependent. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______3. What is the part indicated by the arrows in the illustration below?



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A. Strut rod
B. Control arm
C. Tie-rod
D. Stabilizer bar

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______4. Technician A says rear wheel alignment does not need to be checked after rear suspension service, because many alignment factors are not adjustable. Technician B says an alignment check may indicate whether service was performed correctly. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______5. A client complains of excessive body roll in turns. The most likely cause is a broken:

A. Stabilizer bar
B. Shock absorber
C. Control arm
D. Axle housing

______6. Two types of springs are:

A. Coil and MacPherson
B. Leaf and coil
C. Multileaf and MacPherson
D. Leaf and clamp

______7. The track bar was left off the vehicle during rear-end repair. Which of the following symptoms would occur?

A. Excessive side-to-side body movement
B. Excessive front-to-rear axle movement
C. Both of these
D. Neither of these

______8. A vehicle is found to have a broken leaf in the left rear springs. Technician A says the single spring can be replaced. Technician B says both rear springs should be replaced. Who is right?

A. Technician A
B. Technician B
C. Both Technician A and Technician B
D. Neither Technician A nor Technician B

ACTIVITY ANSWERS

SERVICE REAR SUSPENSION SYSTEMS IV

ACTIVITY SHEET 1

1. A
2. A
3. B
4. B
5. A
6. B
7. A
8. B

JOB SHEET 1

SERVICE REAR SUSPENSION SYSTEMS

IV

OBJECTIVE 8A

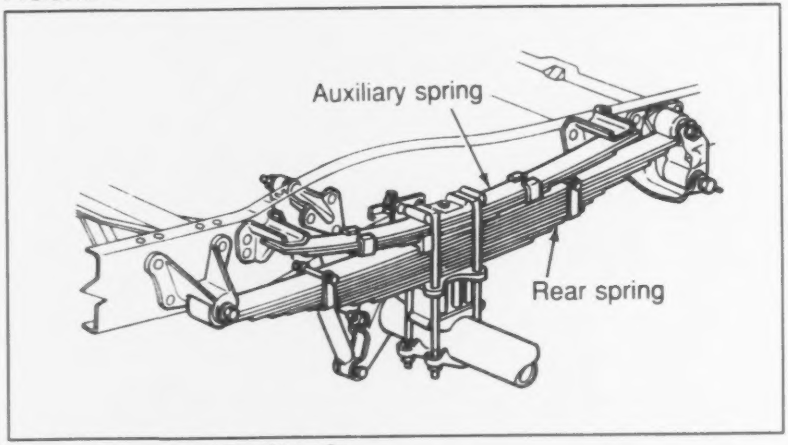
Inspect, remove, and replace nonindependent and semi-independent rear suspension system components.

INTRODUCTION

The nonindependent type of rear suspension is commonly used on rear-wheel drive vehicles with front-mounted engines. Many of the larger passenger cars and most trucks have nonindependent or semi-independent suspensions. Although the designs of these types of suspensions are basic, there are variations. It is necessary for the steering and suspension technician to refer to the correct service manual when servicing nonindependent and semi-independent rear suspension systems.

One variation is the type of spring used. Some nonindependent and semi-independent suspension systems have coil springs. However, leaf springs are also used on nonindependent suspensions. The leaf spring design is an older type of rear suspension and has many design variations. For instance, leaf springs are usually mounted so they are under the axle housing, but on some trucks the springs are above the axle housing. On the Chevrolet Corvette there is only one leaf spring, and it is mounted transversely across the rear. There are other differences in leaf spring mountings. Some heavy-duty leaf springs do not attach to the frame with spring eyes and shackles. Rather, the top leaves of these springs ride on hangers that are connected to the frame. Another design difference is the addition of auxiliary springs. Some leaf spring suspensions used on heavy-duty trucks have auxiliary or helper springs incorporated into the suspension design. Figure 1 on the following page shows a typical rear leaf spring suspension with an auxiliary spring.

FIGURE 1



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Although all leaf spring suspension systems are not identical, many service procedures are similar. The steering and suspension technician should always refer to the vehicle manufacturer's service manual when performing rear suspension service.

Nonindependent and semi-independent coil spring rear suspension systems also have differences. One main difference is the mounting location of the springs. Rear coil springs are mounted on either the rear axle or on the rear lower control arms. Some systems have stabilizer bars, track bars, and/or strut rods; others do not. Additionally, the component connections and locations differ from system to system. Inspection procedures for coil spring systems are similar, but service procedures can vary.

Though procedures vary, there are some guidelines and precautions that should be observed when servicing any vehicle with a nonindependent or semi-independent rear suspension system. These guidelines and precautions are listed below.

Guidelines:

- Position floor jacks carefully. A vehicle can easily be forced off a lift and fall forward if the floor jack supporting the axle is raised too high.
- Be sure to check the vehicle manufacturer's service manual for the proper placement of the jacks. Some vehicles have special areas or plates where jacks and jack stands must be placed. Incorrectly placed jacks and stands can damage the vehicle.

- Note all inspection findings on the Wheel Alignment Check Sheet, indicating those components and parts that are okay and those that should be replaced.

- Inspect shock absorbers visually while the vehicle is raised and perform the bounce test when the vehicle is on the floor.

- Refer to the vehicle manufacturer's service manual or to the shock absorbers manufacturer's instructions to see if any steps should be taken before disconnecting or removing air or gas shock absorbers. For instance, before removing gas shocks, tie or strap the shocks while they are still compressed. Otherwise the shocks will fully extend and will be difficult, if not impossible, to remove. Also, gas shocks must usually be compressed in order to install them.

  NOTE: Gas shock absorbers are pre-sealed units which contain gas instead of air. Often installed in the rear suspension of luxury vehicles, gas shocks frequently require special handling.

- Be careful not to puncture gas shock absorbers and do not apply heat to them.

- Replace the springs in axle pairs. Even if only one spring needs replacement, replace both springs.

- Follow the vehicle manufacturer's instructions when checking the ball joints.

- Rear-wheel alignment should be checked after performing rear suspension service. This alignment check will indicate whether service was performed correctly or whether further measurements and repairs will be required. Alignment procedures will be covered in Unit 6, *Adjust Wheel Alignment*.

- As a part of inspection, measure the vehicle height against the manufacturer's specifications to determine whether the springs have sagged. If the measured height is low, the springs should be replaced or the torsion bars adjusted.

  NOTE: Prior to measurement, be sure the vehicle is prepared according to manufacturer's directions such as a full fuel tank, no load in the trunk, etc.

- One way to check leaf springs is to compare the curvature of the left spring to the right spring. A different in curvatures can indicate a weak or damaged leaf spring.

- Before inspecting the suspension, disconnect the automatic level control system if the vehicle is so equipped.

EQUIPMENT AND MATERIALS

- Vehicle with nonindependent or semi-independent rear suspension
- Appropriate service manual
- Other equipment and materials as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

JOB SHEET 2

SERVICE REAR SUSPENSION SYSTEMS

IV

OBJECTIVE 8B

Inspect, remove, and replace independent rear suspension system components.

INTRODUCTION

Independent rear suspension systems in most cases have more components than nonindependent and semi-independent suspension systems. Because the wheels of vehicles with independent rear suspensions are not firmly connected to one solid axle as in a nonindependent suspension, additional components are needed to provide stability. Struts and control arms control up-and-down and front-to-rear movement of the wheels. They also help to control other forces such as those that occur during braking, acceleration, and cornering.

There are many different independent rear suspension system designs. Several of these designs use coil springs, and many use MacPherson struts. A few others use transversely mounted leaf springs. Rear coil spring suspension systems can have two or four control arms. Mounting positions of the springs differ among designs, too.

Because of these differences and the many different parts involved, independent suspension systems are more costly to repair. However, this type of suspension system is becoming more and more popular, especially in front-wheel drive vehicles. The steering and suspension technician must have the skills necessary to service these systems.

Procedures for inspecting independent rear suspension components are the same as those procedures outlined in the appropriate service manual for nonindependent and semi-independent suspension components. The guidelines listed in Job Sheet 1 also apply to independent rear suspension service. The procedures for checking ball joint wear are the same as those explained in Unit 3, *Service Front Suspension Systems*. The guidelines for servicing MacPherson struts, listed in Unit 3, also apply to rear strut service. Depending on the particular systems, however, there can be additional parts to be inspected and additional inspection procedures. Therefore, the steering and suspension technician must always refer to the vehicle manufacturer's service manual when inspecting and replacing independent rear suspension system components.

EQUIPMENT AND MATERIALS

- Vehicle with independent rear suspension
- Appropriate service manual
- Other equipment and materials as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for the make and model vehicle as equipped.

OBJECTIVE 8C

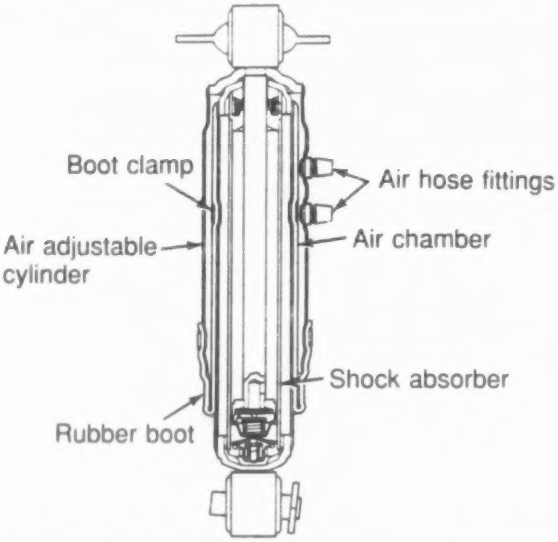
Inspect and replace air shock absorbers.

INTRODUCTION

Some vehicles have factory-equipped air shock absorbers. The regular hydraulic shock absorbers on other vehicles can be replaced with air shock absorbers to maintain the desired ride height.

Air shock absorbers, unlike regular shocks, have special air chambers. Air enters and leaves the air chambers by way of air valves much like the air valves on a vehicle's tires. A typical air shock is shown below in Figure 1.

FIGURE 1



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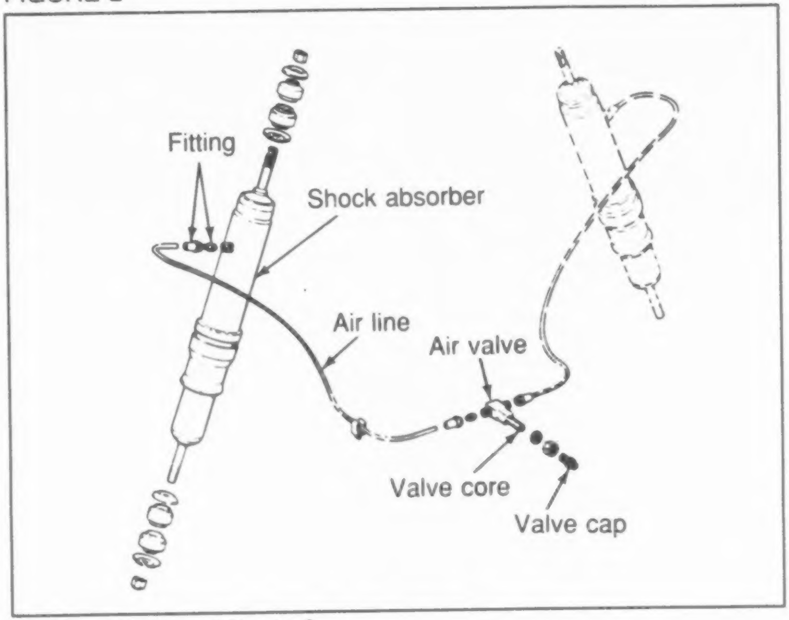
Air shocks are usually used as part of either a manual or automatic leveling control system. One major difference in automatic and manual systems is the source of air for the shocks. In automatic systems, the source of compressed air is located within the vehicle—an electric or, on some older models, vacuum compressor. In manual systems, the shocks must be filled by using some outside source of compressed air, such as from the air compressor in your shop. A manual leveling control system is shown in Figure 2 on the following page.

FIGURE 2



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The actual procedures for air shock replacement may not be extremely complicated. However, there are many differences among leveling control system designs. For this reason, procedures do vary, and the technician should be aware of this. There are some guidelines and precautions that should be observed whenever inspecting and replacing air shock absorbers, and these are listed below.

Guidelines:

- Follow the manufacturer's instructions exactly. Failure to do so could cause damage to the shock absorbers.
- Always disconnect the height sensor on vehicles with automatic level control before allowing the suspension and rear axle to hang free.
- Check for air leakage by applying a soap and water solution to air lines, to fittings, and around air valves. Signs of a poorly operating shock absorber can be caused by an air leak elsewhere in the system.
- Check for pinched lines.

- Clean the connectors and the surrounding areas before disconnecting any air line. This helps prevent the possibility of dirt or other contaminants from entering the air lines.

- Check the shock absorber mountings for worn or damaged bushings and loose mounting nuts.

- Use jacks and jack stands or a lift set at proper lift points.

CAUTION

When disconnecting the air shock from the brackets, the rear suspension should be supported to prevent dropping.

EQUIPMENT AND MATERIALS

- Vehicle with air shock absorbers
- Appropriate service manual
- Other equipment and materials as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

PRACTICAL TESTS

SERVICE REAR SUSPENSION SYSTEMS IV

JOB SHEET 1

Inspect, remove, and replace nonindependent and semi-independent rear suspension system components.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	______	______
2. Prepared the vehicle and work area appropriately.	______	______
3. Performed the inspection following procedure outlined in the vehicle manufacturer's service manual.	______	______
4. Correctly determined whether the components should be replaced.	______	______
5. Removed and replaced the rear suspension system parts and components following the outlined procedure.	______	______
6. Completed the service and the Wheel Alignment Check Sheet correctly.	______	______
7. Observed safety rules and precautions.	______	______
8. Cleaned work area and returned equipment and materials to proper storage.	______	______

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 2

Inspect, remove, and replace independent rear suspension system components.

STUDENT'S NAME ____________________ DATE ____________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Prepared the vehicle and work area appropriately.	_____	_____
3. Performed the inspection following the procedure outlined in the vehicle manufacturer's service manual.	_____	_____
4. Correctly determined whether the components should be replaced.	_____	_____
5. Removed and replaced the rear suspension system parts and components following the outlined procedures.	_____	_____
6. Completed the service and the Wheel Alignment Check Sheet correctly.	_____	_____
7. Observed safety rules and precautions.	_____	_____
8. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TESTS

SERVICE REAR SUSPENSION SYSTEMS IV

JOB SHEET 3

Inspect and replace air shock absorbers.

STUDENT'S NAME ______________ DATE __________

EVALUATOR'S NAME ______________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Prepared the vehicle and work area appropriately.	_____	_____
3. Performed the inspection following procedure outlined in the vehicle manufacturer's service manual.	_____	_____
4. Correctly determined whether the air shock absorbers should be replaced.	_____	_____
5. Removed and replaced the air shock absorbers following the outlined procedures.	_____	_____
6. Completed the service and the Wheel Alignment Check Sheet correctly.	_____	_____
7. Observed safety rules and precautions.	_____	_____
8. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

____

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

WRITTEN TEST

SERVICE REAR SUSPENSION SYSTEMS

IV

NAME ________________________ SCORE ______

OBJECTIVE 1

Select the definitions of terms associated with rear suspension systems. Select the best answer for each term.

______1. **rear-wheel torque**

A. Reactive force occurring when the vehicle begins a forward movement in which the axle housing tries to rotate in the direction opposite that of wheel rotation
B. Reactive force during vehicle braking in which the axle housing tries to rotate in the direction of the wheel rotation before the brakes were applied
C. Reactive force occurring when the vehicle is in motion in which the suspension components try to move in the direction opposite that of the vehicle
D. Reactive force occurring when gears are shifted in which the axle housing rotates opposite the direction of movement

______2. **semi-independent rear suspension**

A. System that allows the suspension components on one side of the vehicle to move separately from components on the other side; movement of one wheel does not directly affect the other wheel
B. System with independent front suspension and nonindependent rear suspension
C. System in which the suspension components of both wheels attach to the same straight axle; movement of one wheel affects the other wheel
D. System in which the suspension components of both control arms are connected to the same axle or frame crossmember and in which the suspension components on one side of the vehicle move separately from the components on the other side; movement of one wheel only slightly affects the other wheel

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______3. **multileaf spring**

- A. Spring made of layers of coils having different spring rates
- B. Suspension system having only one leaf spring
- C. Any system using two or more springs
- D. Leaf spring made of layers of leaves of different lengths

______4. **rear-end wrap-up**

- A. Reactive force occurring when the vehicle is in motion in which the suspension components try to move in the direction opposite that of the vehicle
- B. Condition resulting from the differential turning the axle while friction between the tires and the ground prevents the wheels from turning
- C. Condition in which uncontrolled braking torque forces the rear of the vehicle downward
- D. Condition in which uncontrolled braking torque forces the rear of the vehicle upward

______5. **independent rear suspension**

- A. System in which the suspension components of both control arms attach to the same axle or frame crossmember and in which the suspension components on one side of the vehicle move separately from the components on the other side; movement of one wheel only slightly affects the other wheel
- B. System in which suspension components of both wheels attach to the same straight axle; movement of one wheel affects other wheel
- C. System that allows the suspension components on one side of the vehicle to move separately from the components on the other side; movement of one wheel does not directly affect the other wheel
- D. System in which the front wheels are nonindependent and the rear wheels are independent

______6. **braking torque**

A. Reactive force during vehicle braking in which the axle housing tries to rotate in the direction of the wheel rotation before the brakes were applied
B. Condition in which uncontrolled rear-wheel, driving, and torque force the rear of the vehicle upward
C. Reactive force occurring when the vehicle is in motion in which the suspension components try to move in the direction opposite that of the vehicle
D. Force which continues to push the car as the brakes are applied

______7. **trailing-arm suspension**

A. Independent rear suspension in which the control arms extend rearward from the point of body attachment
B. Independent rear suspension system in which the control arms extend forward from the body attachment point
C. Nonindependent rear suspension system in which no control arms are used; coil springs are welded to the struts
D. Semi-independent or nonindependent rear suspension system in which the control arms extend rearward from the body attachment point

______8. **nonindependent (solid-axle) rear suspension**

A. System that allows the suspension components on one side of the vehicle to move separately from the components on the other side; movement of one wheel does not directly affect the other wheel
B. System in which the suspension components of both wheels attach to the same straight axle housing; movement of one wheel affects the other wheel
C. System in which the suspension components of both control arms attach to the same axle or frame crossmember and in which the suspension components on one side of the vehicle move separately from the components on the other side; movement of one wheel only slightly affects the other wheel
D. System in which the front and rear suspension systems are identical and both axles are constructed from a solid piece of metal

______9. **differential**

A. Reactive force during vehicle braking in which the axle housing tries to rotate in the direction of the wheel rotation before the brakes were applied
B. Assembly that drives both rear axles but allows the wheels to rotate at different speeds during turns
C. Condition resulting from the differential turning the axle while friction between the tires and the ground prevents the wheels from turning
D. Reactive force occurring when vehicle begins a forward movement in which the axle housing tries to rotate in the direction opposite that of wheel rotation

______10. **monoleaf spring**

A. A flat spring replacing systems with two or more springs
B. Leaf springs made of one layer of metal
C. Tapered leaf spring consisting of a single leaf made of metal or fiberglass
D. Springs made of several layers of metal molded into one unit or leaf

OBJECTIVE 2

State the purposes of the rear suspension system. Write the purposes in the following blanks.

1. ______________________________
____
2. ______________________________
____
3. ______________________________
____
4. ______________________________
____
5. ______________________________
____

6. ____

____

OBJECTIVE 3

Describe types of rear suspension systems. Write the correct description for each suspension system listed below.

1. **Coil spring** — ______________________________

____

____

____

2. **Leaf spring** — ______________________________

____

____

____

3. **MacPherson strut** — __________________________

____

____

____

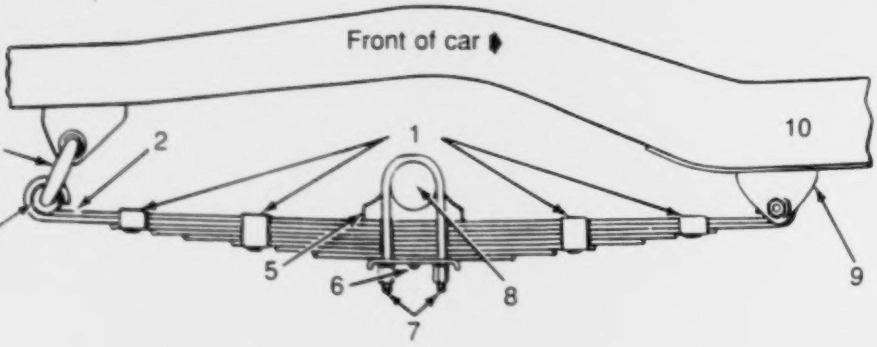
4. **Transverse leaf spring** — ______________________

____

____

____

OBJECTIVE 4 **Label the parts of a multileaf-spring assembly.** Write the letters of the part names in the correct blanks.



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______1. A. Frame

______2. B. Rear axle housing

______3. C. Rebound clips

______4. D. Master spring leaf

______5. E. Spring center bolt

______6. F. Spring eye

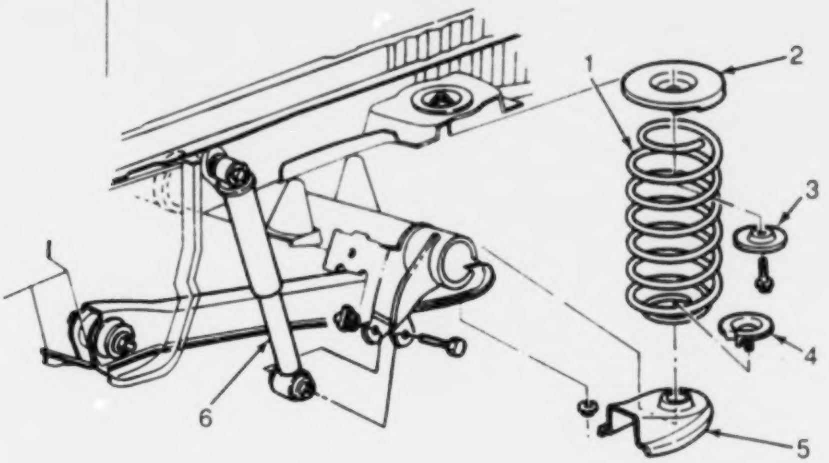
______7. G. Spring hanger

______8. H. Spring seat

______9. I. Spring shackle

______10. J. U-bolt

OBJECTIVE 5 **Label the parts of a coil spring assembly.** Write the letters of the part names in the correct blanks.



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_______1. A. Coil spring

_______2. B. Lower mount and/or insulator

_______3. C. Lower retainer

_______4. D. Rear shock absorber

_______5. E. Upper mount and/or insulator

_______6. F. Upper retainer

OBJECTIVE 6

Match rear suspension parts to their purposes. Write the correct letters in the blanks.

______1. Prevent the car body from moving side-to-side

______2. Controls front-to-rear movement of the rear axle to keep the axle properly aligned and control rear-end wrap-up

______3. Prevent the car body from leaning excessively in sharp turns

______4. Support the vehicle load and control rear-wheel torque

______5. Allow the leaf spring to lengthen or shorten and reduce the shock transferred to the vehicle body

______6. Reduce friction between the spring leaves and reduce noise when the spring flexes

______7. Control front-to-rear movement of the rear axle

______8. Support the vehicle load by using metal or metal alloy coils that compress or expand as necessary

______9. Support the vehicle load in a system that can be adjusted to compensate for changes in the vehicle load

______10. Absorb shock and reduce noise at the component or part connections

______11. Hold the spring leaves together

A. Air shocks

B. Bushings

C. Coil springs

D. Control arms

E. Insulators

F. Leaf springs

G. Rebound clips

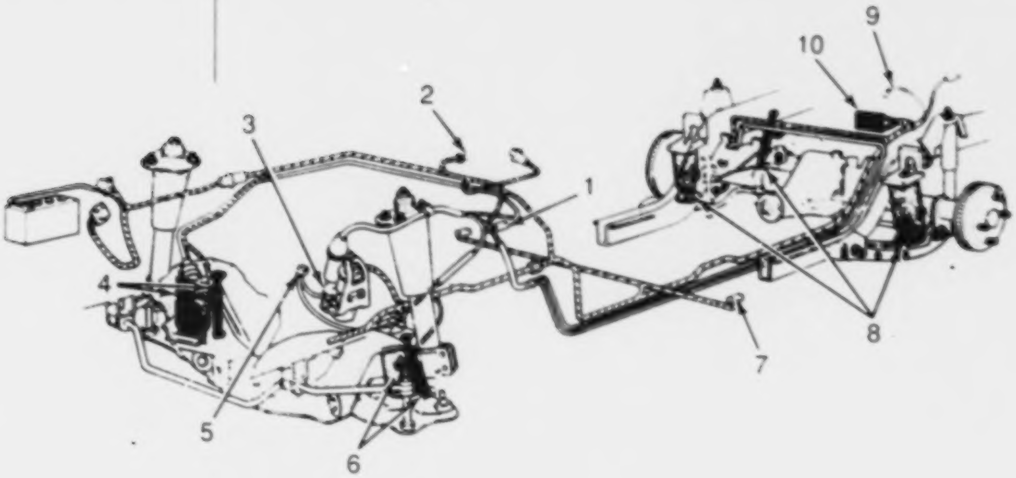
H. Shackles

I. Stabilizer bars (sway bars)

J. Strut rods

K. Track bars

OBJECTIVE 7 **Label the parts of an automatic leveling control system.** Write letters of the part names in the correct blanks. Some names are used more than once.



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_______1.

_______2.

_______3.

_______4.

_______5.

_______6.

_______7.

_______8.

_______9.

______10.

A. Air compressor vent solenoid

B. Air shock and height sensor

C. Brake sensor

D. Compressor relay

E. Computer (electronic control module)

F. Failure warning light

G. Open door sensor switch

H. Rear air shocks and height sensor

I. System diagnostic pigtail

WRITTEN TEST ANSWERS

SERVICE REAR SUSPENSION SYSTEMS IV

OBJECTIVE 1

1. A
2. D
3. D
4. B
5. C
6. A
7. D
8. B
9. B
10. C

OBJECTIVE 2

The answers should include all of the following:

- Supports the weight of the rear part of the vehicle
- Provides a smooth, comfortable ride by allowing the wheels to move up and down with minimum movement of the car body
- Keeps the tires in firm contact with the road
- Maintains the correct vehicle height at the rear of the vehicle
- Keeps the rear wheels in the correct position
- Controls rear-end wrap-up

OBJECTIVE 3

1. Independent, semi-independent, or nonindependent suspension system which uses coil springs on each side of the vehicle between the frame or body and the axle housing or control arms
2. Solid axle suspension system with leaf springs mounted parallel to the frame on each side of the vehicle
3. Independent or semi-independent suspension system with a strut assembly on each side of the vehicle; strut assemblies are mounted between the spindle and the body or frame
4. Independent suspension system with a leaf spring mounted transversely to the frame parallel to the wheel axle; each end of the spring acts as a single spring for that particular side of the vehicle

OBJECTIVE 4

1. C
2. D
3. I
4. F
5. H
6. E
7. J
8. B
9. G
10. A

OBJECTIVE 5

1. A
2. E
3. F
4. C
5. B
6. D

OBJECTIVE 6

1. K
2. D
3. I
4. F
5. H
6. E
7. J
8. C
9. A
10. B
11. G

OBJECTIVE 7

1. C
2. F
3. A
4. B
5. D
6. B
7. G
8. H
9. I
10. E

OBJECTIVE SHEET

PERFORM PRE-ALIGNMENT INSPECTIONS

V

INTRODUCTION

Performing wheel alignment services is an important part of the steering and suspension technician's job. Even more important, however, is completing all the tasks necessary to prepare a vehicle for alignment. This includes inspecting the steering and suspension systems, the wheel bearings, the tire and wheel assemblies and making any necessary adjustments and repairs. Only after this is done can the technician properly perform alignment services.

PREREQUISITES

Before studying this unit, the student should have successfully completed Units 1-4.

UNIT OBJECTIVE

After completing this unit, the student should be able to perform pre-alignment inspections and diagnose alignment problems. The student will demonstrate these competencies by completing the assignment sheets, job sheets, and written test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to:

1. Select the definitions of terms associated with pre-alignment inspections.
2. List the items to be checked during a pre-alignment inspection.
3. Select from a list true statements about the types, sizes, and construction of tires.
4. List and describe the types of wheel balancing machines.
5. Analyze tire wear patterns. (Assignment Sheet 1)
6. Diagnose wheel balance and runout problems. (Assignment Sheet 2)
7. Diagnose alignment problems. (Assignment Sheet 3)
8. Demonstrate the ability to:
    - A. Measure axle and hub runout. (Job Sheet 1)
    - B. Balance wheels. (Job Sheet 2)

PERFORM PRE-ALIGNMENT INSPECTIONS

PREPARATION

- Review the unit and plan your presentation. Study the specific objectives to determine the order in which you will present the objectives.

- Review the teaching suggestions given in the Delivery and Application sections and plan classroom activities. Also note suggestions for media and supplemental materials.

- Plan the presentation to take advantage of student learning styles and accommodate the needs of special students.

- Many multiple-choice test questions (in the Pretests, Assignment Sheets, and Written Test) for this curriculum have been written in a style that is similar to the questions on the ASE certification test. Like ASE questions, the student should select the item that **BEST** answers the question. *The student should make no additional assumptions about a question other than those specifically given in the question.* A special effort has been made to provide good distracters for each question which will make the student think through the answer. It is suggested that the instructor review the answers to every test before reviewing the test with the students so that he or she is not caught off guard by such distracters.

- Obtain films, videotapes, and other media to supplement instruction of this unit. See ordering information in the Suggested Resources section. Include in your selection media that demonstrate job sheet skills. Videotape your own demonstrations of job sheet procedures if you are unable to obtain suitable media.

- Obtain competency profiles.

  NOTE: Competency profiles for this book are available from the Curriculum and Instructional Materials Center, Oklahoma Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364.

- Prepare the classroom and shop. Display posters, charts, safety signs, etc., that emphasize pre-alignment service. Have articles, specification guides, and other references about pre-alignment inspections available for student use.

- Discuss the purpose of pretesting with the students. Explain that they will be asked to complete a written pretest and that they will be required to demonstrate assignment sheet competencies and job sheet skills as part of the pretesting process.
- Provide the students with the equipment and materials necessary to complete the pretest. Administer the pretest.
- Assess student competencies. Consider the results of the student assessments of the unit objectives as you prepare your presentation for each objective.

DELIVERY

Unit Introduction

- Discuss the introduction to the unit. (See Objective Sheet.)
- Discuss the unit objective and then the specific objectives. Emphasize how accomplishing the specific objectives will lead to meeting the unit objective and how reaching the unit objective is vital to becoming an automotive steering and suspension technician. Relate the objective to your introduction and to material previously covered.

Objective 1 Select the definitions of terms associated with pre-alignment inspections.

- Show the students examples of as many of the terms listed in this objective as possible.
- Explain the terms *static balance* and *dynamic balance* and discuss the illustrations presented with each term.
- Discuss the terms *radial runout* and *lateral (axial) runout* and explain how excessive runout affects wheel movement when the vehicle is driven.

Objective 2 List the items to be checked during a pre-alignment inspection.

- Discuss each of the items listed in this objective. Point out to the students that inspection of the wheel bearings, suspension system, and steering system has been covered in previous units and that during pre-alignment inspections, they will have the opportunity to use the information learned in these units.

- Discuss the boxed material, "Wheel Pre-Alignment Inspections."

Objective 3 Select from a list true statements about the types, sizes, and construction of tires.

- Show the students examples of each tire type.
- Discuss how different types of tires perform.

Objective 4 List and describe the types of wheel balancing machines.

- Discuss each type presented and point out whether each balances wheels dynamically, statically, or both.
- Explain the advantages of each type of balancing machine and discuss the types most commonly used.
- Explain to the students the basic operation of each of the three types of machines.

APPLICATION

Objective 5 Analyze tire wear patterns. (Assignment Sheet 1)

- Have the students read Supplement 1, Diagnosing Tire and Alignment Problems, and discuss it in class.
- Point out different kinds of problems that tire wear patterns can indicate: wheel imbalance, improper tire inflation, incorrect alignment settings, etc.
- Have the students complete Assignment Sheet 1. When the students have completed the assignment, discuss it in class.

Objective 6 Diagnose wheel balance and runout problems. (Assignment Sheet 2)

- Have the students read Supplement 2, Diagnosing Wheel Balance and Runout Problems, and discuss it in class.
- Explain to the students how different vehicle speeds affect problems caused by excessive runout, wheel imbalance, and improper alignment. Discuss which problems occur at almost all speeds and which occur only at certain speeds. Include in your discussion the causes of vibrations that worsen at higher speeds.

- Show the media presentation, *The Unbalanced Wheel*, and discuss the effects of unbalanced wheels.

- Have the students complete Assignment Sheet 2. When they have completed the assignment, discuss it in class.

Objective 7 Diagnose alignment problems. (Assignment Sheet 3)

- Review the information in Supplement 1, Diagnosing Tire and Alignment Problems. Discuss the information about *toe*, *caster*, and *camber*.

- Show the media presentation, *Problems—Causes and Corrections.*

- Explain the effects that negative and positive camber and caster have on a turning vehicle.

- Explain why vehicles with power steering systems usually have more positive camber than those with manual steering systems.

- Have the students complete Assignment Sheet 3. When they have completed the assignment, discuss it in class.

Objective 8A Measure axle and hub runout. (Job Sheet 1)

- Discuss *match-mounting* and explain how match-mounting can correct runout problems in some cases. Explain that a tire should never be rotated on the rim more than halfway (or more than 180 degrees) around the rim. Also mention that most tire manufacturers no longer put match marks on their tires.

- Review the procedures for measuring lateral and radial runout of both the tire and the wheel. If necessary, refer to Job Sheet 2, Measure Tire and Wheel Runout, in Unit A-4, *Apply Math and Related Measuring*, of *Introduction to Automotive Service*.

- Explain how tire and wheel radial and lateral runout can be checked with the tire and wheel assembly off the car by using a computerized balancing machine.

- Explain to the students when axle and hub runout measurement is necessary.

- Have the students find runout specifications in various vehicle manufacturers' manuals.

- Discuss different vehicle manufacturers' recommendations for zeroing the dial indicator when measuring wheel stud runout.

- Discuss the equipment and materials used in Job Sheet 1. Review applicable safety rules and precautions and the guidelines given in the job sheet introduction.

- Demonstrate Job Sheet 1. Have the students practice Job Sheet 1 until they are ready to take the practical test.

Objective 8B Balance wheels. (Job Sheet 2)

- Show the students how to improve dynamic balance when static balancing a wheel by moving the weights (one on each side of the rim) apart, away from the balance mark.

- Use a wooden wheel and a tack to illustrate dynamic and static imbalance. Cut a 6- or 8-inch circle from a 1-inch-thick board, drill a hole through the board at the center and insert a metal rod through the hole, making sure there is adequate clearance to allow the board to rotate freely on the rod. Place a tack on the side of the board and spin the board to illustrate dynamic imbalance and how it affects wheel movement. Remove the tack and place it on the edge of the board. Spin the board to illustrate static imbalance. Point out that the tack (heavy spot) is always at the bottom when the wheel stops rotating. Explain how static imbalance affects wheel movement.

- Show the media presentations, *The Unbalanced Wheel* and *Operating the Strobe Electronic Indicator*.

- Discuss the equipment and materials used in Job Sheet 2. Review applicable safety rules and precautions and the guidelines given in the job sheet introduction.

- Demonstrate Job Sheet 2. Have the students practice Job Sheet 2 until they are ready to take the practical test.

Unit summary activity

- Discuss Activity Sheet 1, Answer General Questions About Pre-Alignment Inspections. The purpose of the activity is to provide the students with the opportunity to practice answering questions similar in content and style to those found on the actual ASE certification test. Keep this in mind when discussing the activity.

EVALUATION

- Give the written test.
- Give the practical tests and evaluate the tests on the forms provided.
- Reteach and retest as required.
- Complete the appropriate section of competency profiles.

SUGGESTED RESOURCES

Resources used in developing unit

- Bacon, Miles E. *Automotive Steering, Suspension, and Wheel Alignment Shop Manual.* New York: Gregg Division, McGraw-Hill Book Co., 1988.
- Coghlan, David A. *Automotive Chassis Systems: Steering, Suspension, Alignment, and Brakes*, 2nd ed. Boston: Breton Publishers, A Division of Wadsworth, Inc., 1985.
- Crouse, William H., and Donald L. Anglin. *Automotive Brakes, Suspension, and Steering.* New York: Gregg Division, McGraw-Hill Book Co., 1983.
- Duffy, James E. *Modern Automotive Mechanics.* South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1985.
- Ellinger, Herbert E., and Richard B. Hathaway. *Automotive Suspension and Steering: Theory and Service.* Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1989.
- *Ford 1987 Car Shop Manual, Body/Chassis/Electrical: Lincoln Town Car, Ford Crown Victoria, Mercury Grand Marquis.* Dearborn, Michigan: Ford Parts and Service Division, Training and Publications Department, 1986.

- *Ford 1988 Car Shop Manual, Vol. C — Body/Chassis/ Electrical: Tempo, Topaz, Escort.* Dearborn, Michigan: Ford Parts and Service Division, Training and Publications Department, 1987.
- *Ford 1988 Truck Shop Manual: Aerostar.* Dearborn, Michigan: Ford Parts and Service Division, Training and Publications Department, 1987.
- *1986 Chrysler Engine-Chassis-Body Service Manual: 1986 Front Wheel Drive Passenger Vehicles: Lancer, Daytona, New Yorker, Dodge 600, Aries, Omni, LeBaron GTS, Laser, LeBaron, Caravelle, Reliant, Horizon.* Centerline, Michigan: Chrysler Corp., 1985.
- *1988 Celebrity Service Manual.* Warren, Michigan: General Motors Corp., Chevrolet Motor Division, 1987.
- *1990 Chevrolet Light Duty Truck Service Manual: C-K Truck Models.* Warren, Michigan: General Motors Corp., Chevrolet Motor Division, 1989.
- *Steering, Suspension, Wheel Alignment and Balance: Student Reference Book.* Centerline, Michigan: Chrysler Corp. Service and Parts Operations, Training Program Development Department, n.d.
- Stockel, Martin W., and Martin T. Stockel. *Auto Service and Repair.* South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1984.

Media

Spelling and definitions of terminology used in automotive service are not standardized. Media selected to supplement and reinforce material taught in this book may or may not use the same spelling and definitions. Although such deviations should not restrict classroom use of supplemental materials, its existence may confuse some students.

- *Operating the Strobe Electronic Indicator.* 16 minutes, color slides on video tape. Bergwall Productions, Inc., P.O. Box 238, Garden City, NY 11530-0238, phone 1-800-645-3565. Demonstrates how to operate a strobe electronic indicator.

- *Problems-Causes and Corrections.* 10 minutes, color slides on video tape. Bergwall Productions, Inc., P.O.Box 238, Garden City, NY 11530-0238, phone 1-800-645-3565. Addresses front-end problems, including wander, pulling right or left, and tire wear and discusses necessary corrections.

  NOTE: This video is one of four in the series titled, *The Front-End Explained.*

- *Tire Problem Analysis.* 109-frame filmstrip with record or cassette, and student text. Ford Parts and Service Division, Ford Service Publications, P.O. Box 07150, Detroit MI 48207.

- *Tire Wear—Passenger Car.* 5-slide set. Hunter Engineering Co., 11250 Hunter Dr., Bridgeton, MO 63044. Illustrates tire wear patterns.

- *Unbalanced Wheel, The.* 8 minutes, color slides on video tape. Bergwall Productions, Inc., P.O. Box 238, Garden City, NY 11530-0238, phone 1-800-645-3565. Explains static and dynamic balance, how an unbalanced wheel acts, what causes vibration, and how steering linkage parts are affected by unbalanced wheels.

Form 1617 6 80
Supersedes 1617 11 77

WHEEL ALIGNMENT CHECK SHEET

NAME ______________________ MAKE ____________ YEAR ________
ADDRESS ______________________ MODEL ____________ COLOR ________
CITY ____________ STATE ______ ZIP ______ LICENSE ____________________
PHONE ____________ OFFICE PHONE ____________ MILEAGE ____________ DATE ________

PRE-ALIGNMENT INSPECTION

- ☐ NORMAL VEHICLE LOAD
- ☐ TIRE PRESSURES
- ☐ UNEVEN & WORN TIRES
- ☐ WHEEL BEARINGS
- ☐ DRAGGING BRAKES
- ☐ SHOCK ABSORBERS (STRUTS)
- ☐ BALL-JOINTS (KING-PINS)
- ☐ IDLER ARM
- ☐ STABLIZER
- ☐ TIE-RODS & ENDS
- ☐ STEERING ARMS
- ☐ PITMAN ARM
- ☐ SPINDLE
- ☐ BUSHINGS
- ☐ REAR AXLE
- ☐ STEERING WHEEL

LEFT FRONT	CAMBER ANGLE	CASTER ANGLE	TOE
● INITIAL READING			
● FACTORY SPEC			
● FINAL SETTING			

RIGHT FRONT	CAMBER ANGLE	CASTER ANGLE	TOE
● INITIAL READING			
● FACTORY SPEC			
● FINAL SETTING			

TOTAL TOE (FINAL SETTING)

REAR	REAR TOE		REAR CAMBER	
	LEFT	RIGHT	LEFT	RIGHT
● INITIAL READING				
● FACTORY SPEC				
● FINAL SETTING				
● TOTAL TOE (FINAL SETTING)				

THRUST ANGLE	
LEFT	RIGHT
FINAL	

	STEERING AXIS INCLIN	INCLUDED ANGLE	WHEEL SET BACK
LEFT			
RIGHT			
SPEC			

TURNING ANGLE		
R	IN	
	OUT	
L	IN	
	OUT	

● CHECK ALL WHEELS & TIRES . . .

CONDITION	LF	RF	LR	RR
PRESSURE				
RUN OUT				
OUT OF ROUND				
EXCESSIVE WEAR				
BALANCE				

● TORISON-BAR VEHICLES ONLY . . .

SUSPENSION HEIGHT		
INITIAL READINGS		
FACTORY SPECS		
FINAL SETTINGS		

● TRUCKS ONLY . . .

FRAME ANGLE	

SUSPENSION HEIGHT LEFT	RIGHT

REMARKS ______________________________
____
____
____
____

HUNTER

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PRETEST ANSWERS

PERFORM PRE-ALIGNMENT INSPECTIONS V

EVALUATOR NOTE

Use the following answer key to check student answers to pretest questions. To determine the students' individual study requirements from the pretest results, use the following table, which shows the correlation between the objectives and pretest questions. Counsel students individually on pretest results and study requirements.

TABLE

Correlations between objectives and pretest questions:

Objective	Question
1	1, 9, 12
2	2, 10
3	26, 27
4	3, 11
5	4, 13, 18
6	5, 14, 19, 24
7	6, 15, 20
8A	7, 16, 22
8B	8, 17, 21, 23, 25

ANSWER KEY

1. B
2. B
3. C
4. D
5. D
6. A
7. C
8. D
9. C
10. D
11. A
12. B
13. C
14. B
15. A
16. C
17. A
18. D
19. B
20. C
21. D
22. B
23. A
24. C
25. D
26. A
27. D

PRETEST

PERFORM PRE-ALIGNMENT INSPECTIONS

V

NAME ______________________________ SCORE ________

DIRECTIONS

Read the following questions and problems. Select the item that best answers the question or solves the problem and write the correct letter in the blank.

______1. Which of the following statements best defines *wheel alignment*?

A. Process of checking only the angles of steering and suspension geometry that are adjustable and making the necessary corrections so that the wheels track properly

B. Process of checking and correcting those angles of the steering and suspension geometry that are adjustable so the vehicle will steer and track properly without producing abnormal tire wear or undesirable steering characteristics

C. Process of checking and correcting the balance of the tire and wheel assembly so the vehicle will steer and track properly without producing abnormal tire wear or undesirable steering characteristics

D. Process of checking the angles of steering geometry that affect the vehicle steering

______2. Which of the following items are **not** normally checked during pre-alignment inspection?

A. Tire and wheel assemblies

B. Electrical system

C. Wheel bearings

D. Steering system components and operation

______3. Which of the following statements best describes the *off-car* wheel-balancing machine?

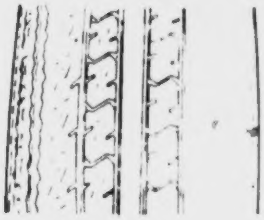
A. Balances the tire and wheel assembly removed from the vehicle by using a bubble to indicate whether part of the assembly is heavier than other parts; checks static balance only

B. Balances the tire and wheel assembly together with the hub and brake drum or rotor by spinning the assembly while mounted and indicating the vibration due to imbalance by either a mechanical or electronic device; some types check only the dynamic balance, others check both the static and dynamic balance

C. Balances the tire and wheel assembly removed from the vehicle by spinning the assembly and indicating the vibration due to imbalance by either an electronic or hand-operated device; some types check only dynamic balance, others check both static and dynamic balance

D. None of the above

______4. Which of the following conditions could cause the tire wear pattern illustrated below?



Used with permission of Ford Motor Co.

A. Incorrect caster

B. Excessive camber

C. Incorrect toe

D. Both B and C

______5. When you test drive a vehicle, you find that it vibrates. Which of the following is the **most** likely cause?

A. Excessive tire radial runout
B. Improper tire inflation
C. Excessive wheel radial runout
D. Out of balance tire and wheel assemblies

______6. A customer brings in his car to your shop for alignment and complains of vehicle wander. If the steering and suspension systems are in good working condition, which of the following alignment problems could cause the car to wander?

A. Excessive negative caster of both front wheels
B. Excessive positive caster of both front wheels
C. Excessive negative camber of both front wheels
D. None of the above

______7. Technicians A and B are discussing runout. Technician A says tire or wheel runout can cause vehicle vibration. Technician B says axle or hub runout can cause vibration. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______8. Which of the following statements about wheel balancing is **not** correct?

A. Tape-on weights are used on aluminum wheels
B. Clip-on weights are available in various sizes
C. Placement of tape-on weights for static balancing is different than placement for dynamic balancing
D. Clip-on weights are attached to the rim flange for dynamic balancing and are attached near the drop-center section of the wheel for static balancing

_____9. *Measurement of the variation of an object's circumference or out-of-roundness* is the definition of which of the following?

A. Runout
B. Lateral runout
C. Radial runout
D. Scrub radius

_____10. Which of the following items should be checked during pre-alignment inspection?

A. Suspension system components and operation
B. Wheel bearings
C. Vehicle height
D. All of the above

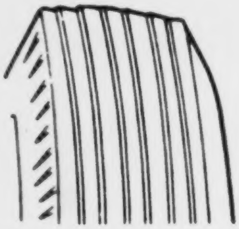
_____11. Which of the following statements best describes an *on-car* wheel-balancing machine?

A. Balances the tire and wheel assembly together with hub and brake drum or rotor by spinning the assembly while mounted and indicating the vibration due to an imbalance by either a mechanical or electronic device; some types check only dynamic balance, others check both static and dynamic balance
B. Balances the tire and wheel assembly removed from vehicle by using a bubble to indicate whether part of assembly is heavier than other parts; checks static balance only
C. Balances the tire and wheel assembly removed from the vehicle by spinning the assembly and indicating the vibration due to imbalance by either an electronic or hand-operated device; some types check only dynamic balance, others check both static and dynamic balance
D. Either B or C

_____12. Which of the following statements best defines *static balance*?

A. Condition of the tire and wheel assembly having the weight equally distributed in respect to the center line of the tire and wheel assembly
B. Condition of a tire and wheel assembly having the weight equally distributed around the wheel
C. Condition of the tire and wheel assembly having no heavy spots
D. Condition of the tire and wheel assembly having weights placed at appropriate points on the wheel rim

_____13. Which of the following conditions could cause the tire wear pattern illustrated below?



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A. Incorrect caster
B. Excessive camber
C. Incorrect toe
D. Both B and C

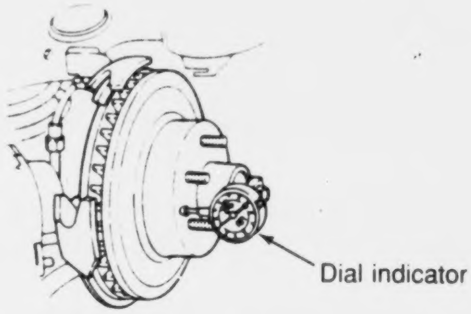
_____14. When you test drive a vehicle, you can feel no excessive shimmy. However, when you inspect the front tires, you find that one tire has excessive cupping. What could be the cause of this?

A. Dynamic imbalance
B. Static imbalance
C. Excessive tire lateral runout
D. Both A and C

_____15. While checking the camber angles of a vehicle's front wheels, you find the camber angle of the left front wheel is 1¼° and the camber of the right front wheel is ½°. What could these camber settings cause?

A. Vehicle pull to the left
B. Vehicle pull to the right
C. Excessive wear on the outer side of right front tire
D. Excessive wear on the inner side of left front tire

_____16. What is illustrated in the drawing below?



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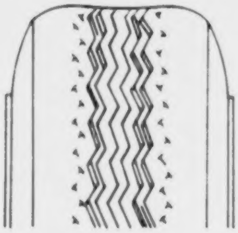
A. Placement of the dial indicator when measuring hub radial runout
B. Placement of the dial indicator when measuring axle radial runout
C. Placement of the dial indicator when measuring hub lateral runout
D. Placement of the dial indicator when measuring axle lateral runout

_____17. To properly balance a tire and wheel assembly, the technician must:

A. Determine what size of weights to use and where they must be placed
B. Determine when the assembly was last balanced
C. Use clip-on weights on all wheel types for correct balance
D. Both A and C

_____18. Which of the following conditions could cause the tire wear pattern illustrated below?



Used with permission of Chrysler Corp.

A. Incorrect camber
B. Incorrect toe
C. Overinflation
D. Underinflation

_____19. While test driving a front-wheel drive car, you notice a shimmy while driving at a speed of 55 miles per hour. However, the vibration is not present at speeds above or below 55. What is the **most** likely cause of the shimmy?

A. Static imbalance
B. Dynamic imbalance
C. Excessive lateral wheel runout
D. Excessive radial wheel runout

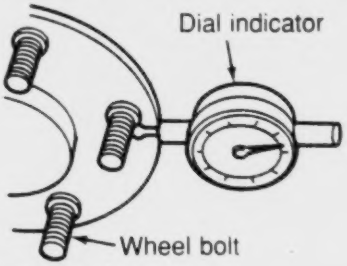
_____20. A customer brings her car to your shop to have the wheels aligned. When you inspect the tires, you find that the outside shoulders of both tires show excessive wear; in fact, the tire edges looked feathered. What alignment problem would **most** likely cause this type of tire wear?

A. Excessive negative camber of both wheels
B. Excessive positive caster of both wheels
C. Excessive toe-in
D. Excessive toe-out

_____21. Which of the following statements is true?

A. Wheels should be balanced every 10,000 miles or once a year
B. Wheels should be balanced after repairing a tire puncture
C. Wheels should be balanced if a wheel weight has been lost
D. All of the above

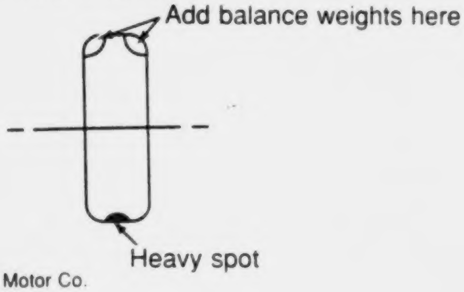
_____22. What is illustrated in the drawing below?



Used with permission of Ford Motor Co.

A. Placement of the dial indicator when measuring hub radial runout
B. Placement of the dial indicator when measuring wheel bolt runout
C. Placement of the dial indicator when measuring hub lateral runout
D. Placement of the dial indicator when measuring axle lateral runout

______23. Technician A says the illustration below shows correct weight placement to balance a tire and wheel assembly statically. Technician B says it shows correct weight placement to balance a tire and wheel assembly dynamically. Who is correct?



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A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______24. When test driving a vehicle, you feel vibration at speeds below 35 miles per hour but not at speeds above. What is the **most** likely cause of this vibration?

A. Static imbalance of the rear wheels
B. Dynamic imbalance of the front wheels
C. Excessive wheel or tire lateral (axial) runout
D. Incorrect alignment settings

______25. Which of the following statements about wheel balancing is correct?

A. Tires must be replaced before wheels are balanced
B. Dynamic balance must be checked before a wheel is balanced statically
C. Procedures for using different on-car balancing machines are the same
D. None of the above

______26. Two types of tire sizing are:

A. Alpha-numeric and metric
B. Alpha-numeric and bar-coded
C. Metric and standard
D. Metric and bar-coded

______27. Three types of tire construction are:

A. Tubeless, bias ply, and radial
B. Single ply, bias ply, and belted bias
C. Single ply, bias ply, and radial
D. Bias ply, belted bias, and radial

PERFORM PRE-ALIGNMENT INSPECTIONS *V*

OBJECTIVE 1

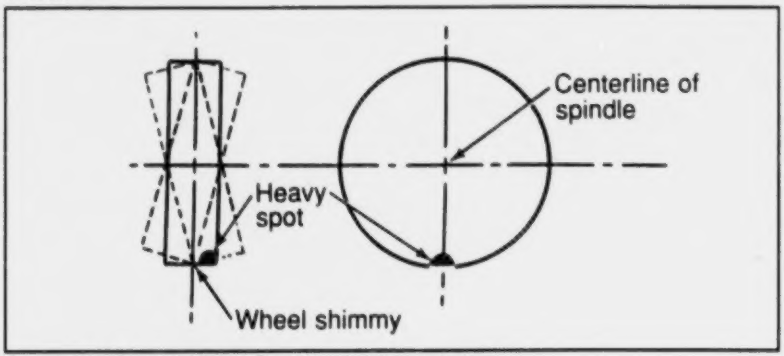
Select the definitions for terms associated with pre-alignment inspections.

dynamic balance — Condition of the tire and wheel assembly having the weight equally distributed in respect to the center line of the tire and wheel assembly (Figure 2)

NOTE: A tire and wheel assembly with a heavy spot on the tread area close to the sidewall is out of balance dynamically. (Figure 1)

EXAMPLE:

FIGURE 1



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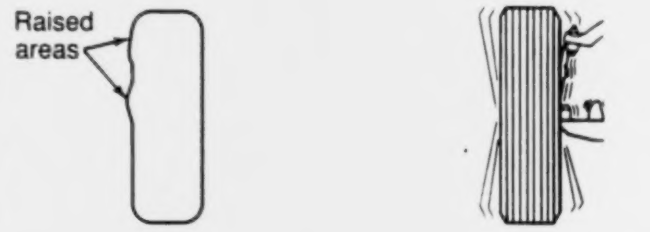
lateral runout — Measurement of the variation of the side surface of an object (Figure 2)

NOTE: Lateral runout can cause a tire and wheel assembly to wobble (as shown in Figure 2) when the vehicle is driven.

516

EXAMPLE:

FIGURE 2



Tire with excessive lateral runout

Wheel wobble caused by excessive lateral runout

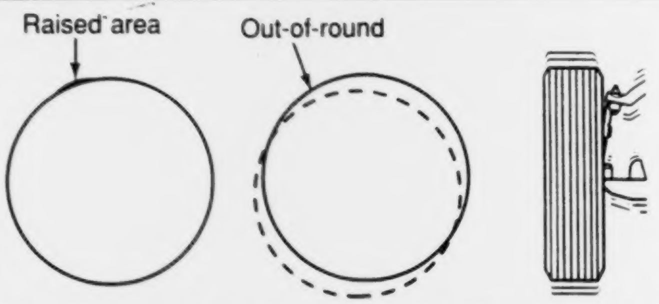
Illustration (right) used with permission of Chrysler Corp.

radial runout — Measurement of the variation of an object's circumference or out-of-roundness (Figure 3)

NOTE: Radial runout can cause a tire and wheel assembly to hop or tramp when the vehicle is driven. This is because, as the wheel rotates, the distance from the center of the wheel to the ground is not the same. A tire and wheel assembly with radial runout (Figure 3) is said to be *out-of-round*.

EXAMPLE:

FIGURE 3



Tire with excessive radial runout

Wheel tramp caused by excessive radial runout

Illustration (right) used with permission of Chrysler Corp.

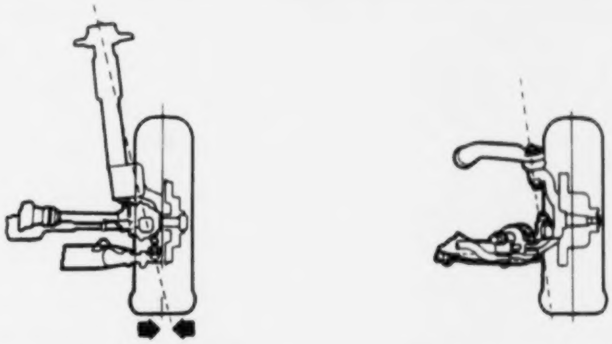
runout — The distance the surface or edge of a rotating part moves in or out during rotation

scrub radius — Distance between the points where the center line of the tire and a line through the suspension pivot points contact the road surface (Figure 4)

NOTE: If the intersection of these two lines is above the road surface, the scrub radius is *negative*. The scrub radius is *positive* if the intersection is below the road surface. (Figure 4)

EXAMPLE:

FIGURE 4



NEGATIVE SCRUB RADIUS **POSITIVE SCRUB RADIUS**

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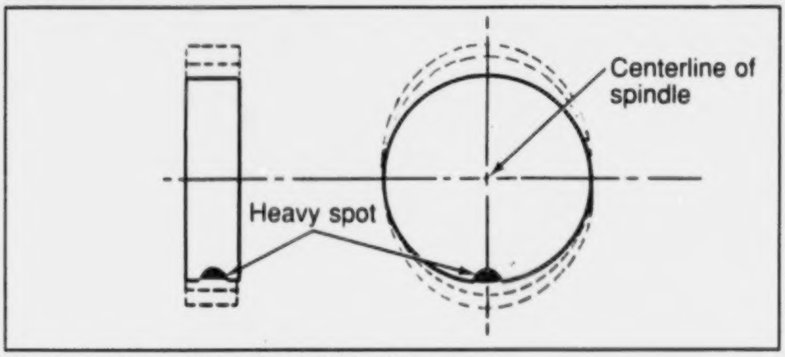
shimmy — Side to side movement; dynamic imbalance

static balance — Condition of a tire and wheel assembly having the weight equally distributed around the wheel (Figure 5)

NOTE: A tire and wheel assembly with a heavy spot across the tire tread or on the middle part of the tread area is out of balance statically. (Figure 5)

EXAMPLE:

FIGURE 5



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wheel alignment — Process of checking and correcting those angles of the steering geometry that are adjustable so the vehicle will steer and track properly without producing abnormal tire wear or undesirable steering characteristics

NOTE: Checking and adjusting angles such as toe, camber, and caster ensures that the tire and wheel assemblies are correctly positioned on the vehicle.

wheel balancing — Process of checking and correcting the balance of a tire and wheel assembly so the weight is equally distributed

wheel tramp — Up and down out-of-round; static imbalance

OBJECTIVE 2 **List the items to be checked during a pre-alignment inspection.**

- **Tire and wheel assemblies**

  NOTE: The tires should be checked for wear patterns or damage and should be properly inflated. They should be checked to make sure they are the same size, type, and construction. Wheels should be both statically and dynamically balanced before the alignment is checked.

- **Wheel bearings**

  NOTE: Wheel bearings should be properly adjusted. If they cannot be adjusted to specifications, they should be removed, inspected, and replaced if necessary.

- **Vehicle height**

  NOTE: The vehicle height must be within manufacturer's specifications before the wheel alignment can be performed.

- **Suspension system components and operation**

- **Steering system components and operation**

WHEEL PRE-ALIGNMENT INSPECTIONS

As you can see from the list above, there are many items to be inspected before wheel alignment can be performed. In many instances, it is impossible to adjust wheel alignment angles to specifications if the items listed are not in good working order or not adjusted to specifications. Because conditions caused by problems with tires, wheel bearings, suspension system components, or steering system components are similar to conditions caused by alignment problems, it is important that the steering and suspension technician find and correct any problems before attempting alignment procedures. If the bearings are not adjusted properly, they should be removed, inspected, repacked, and replaced as necessary. By doing so, the technician will be able to better diagnose wheel alignment problems.

OBJECTIVE 3 **Select from a list true statements about the types, sizes, and construction of tires.**

TYPES

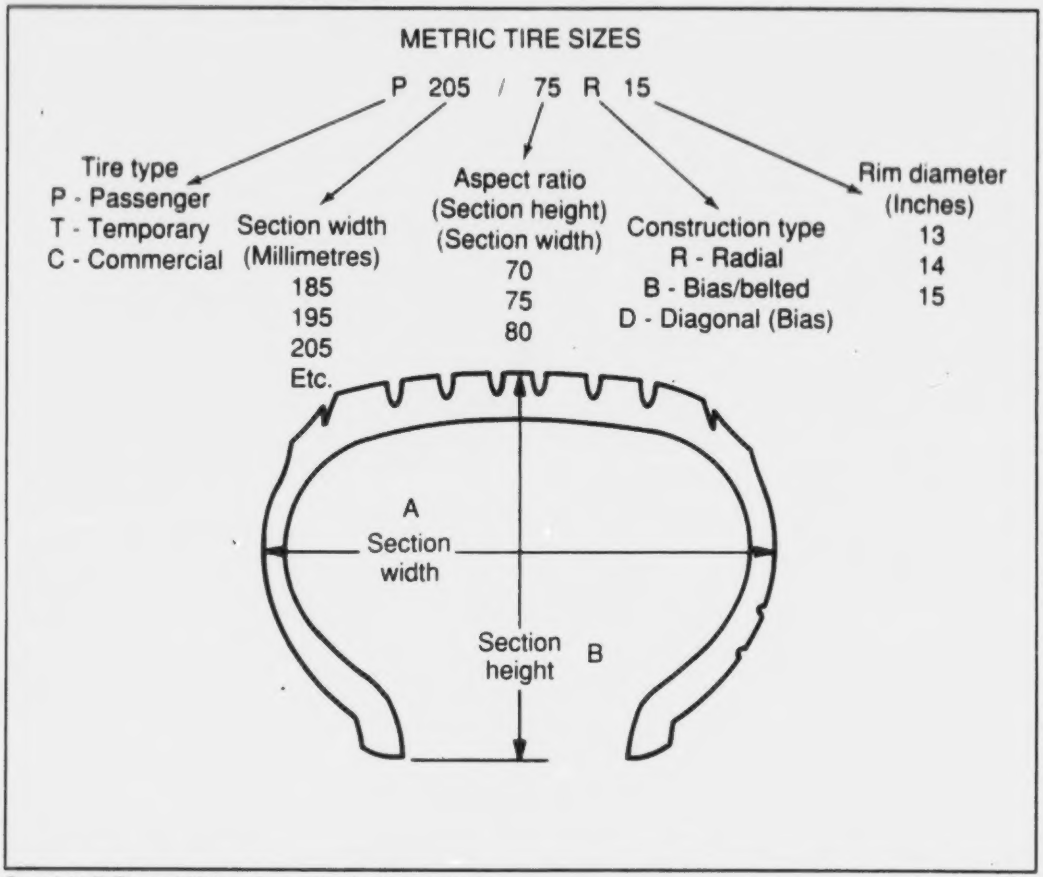
- **Tubeless pneumatic tires** — The tires normally used today which are filled with air that supports the weight of the car
- **Compact self-sealing tires** — Tires with an inner coating of sealant that stops air leakage when the tire is punctured
- **Retreads** — Old tires with new tread applied by heat and pressure

SIZES

NOTE: Tire sizes are alpha-numeric or metric. Tire sizes are actually a series of measurements or details about the tire.

- **Metric sizes** (Figure 6)
  - — Tire type
  - — Section width
  - — Aspect ratio
  - — Construction type
  - — Rim diameter

FIGURE 6


METRIC TIRE SIZES
P 205 / 75 R 15
Tire type
P - Passenger
T - Temporary
C - Commercial
Section width
(Millimetres)
185
195
205
Etc.
Aspect ratio
(Section height)
(Section width)
70
75
80
Construction type
R - Radial
B - Bias/belted
D - Diagonal (Bias)
Rim diameter
(Inches)
13
14
15
A
Section
width
Section
height
B

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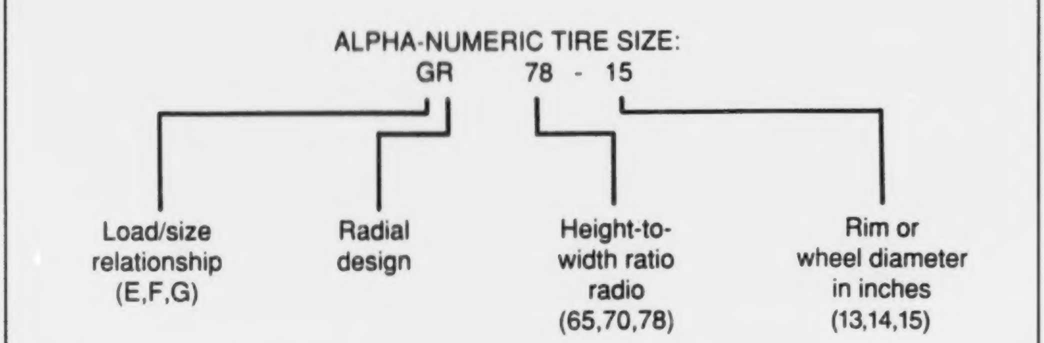
- **Alpha-numeric sizes** (See Figure 7 on the next page.)
  - — Load/size relationship
  - — Tire type
  - — Height-to-width ratio
  - — Rim or wheel diameter

FIGURE 7


ALPHA-NUMERIC TIRE SIZE:
GR 78 - 15
Load/size relationship (E,F,G)
Radial design
Height-to-width ratio radio (65,70,78)
Rim or wheel diameter in inches (13,14,15)

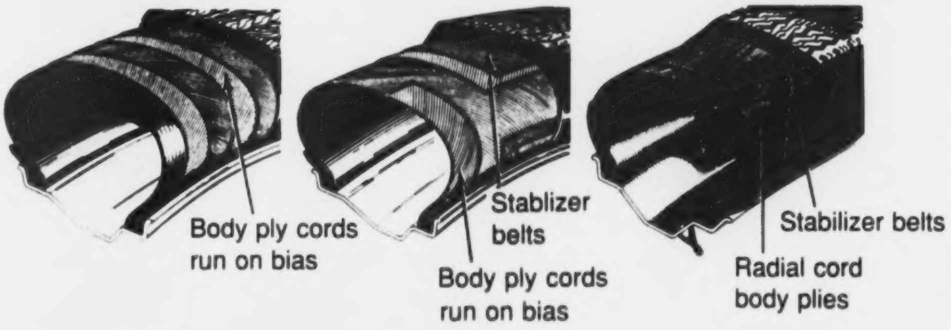
Construction (Figure 8)

- **Bias ply** — An older tire design with plies, or layers, with perpendicular angles placed on top of the other and the tread bonded to the top ply

- **Belted bias** — Tires with bias plies and stabilizer belts under the tread

- **Radial** — Tires with plies running from bead to bead and stabilizer belts under the tread

FIGURE 8


Body ply cords run on bias
Stablizer belts
Body ply cords run on bias
Stabilizer belts
Radial cord body plies

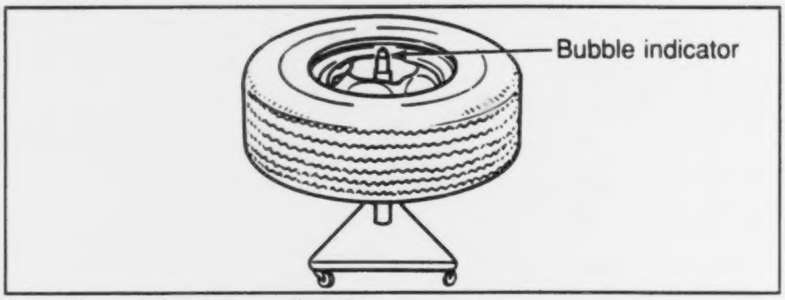
BIAS PLY TIRE **BELTED BIAS** **RADIAL**

OBJECTIVE 4 **List and describe the types of wheel-balancing machines.**

- **Bubble-type** — Balances the tire and wheel assembly removed from the vehicle by using a bubble to indicate whether part of the assembly is heavier than other parts; checks static balance only (Figure 9)

  EXAMPLE:

FIGURE 9



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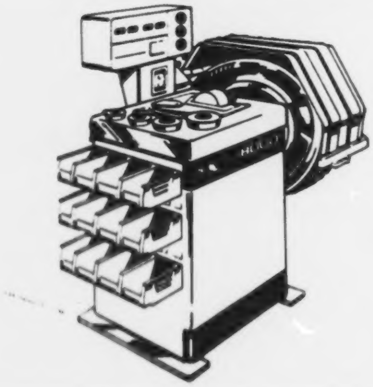
- **Off-car** — Balances the tire and wheel assembly removed from the vehicle by spinning the assembly and indicating vibration due to imbalance by either an electronic or hand-operated device; some types check only dynamic balance, others check both static and dynamic balance (Figure 10)

  NOTE: Most off-car balancers are computerized.

  EXAMPLE:

FIGURE 10

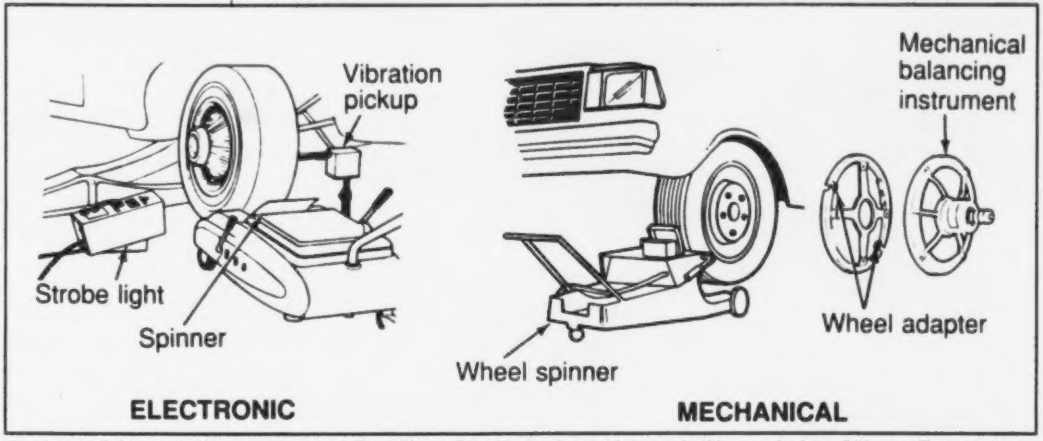


- **On-car** — Balances the tire and wheel assembly together with the hub and brake drum or rotor by spinning the assembly while mounted and indicating the vibration due to imbalance by either a mechanical or electronic device; some types check only dynamic balance, others check both static and dynamic balance (Figure 11)

  NOTE: On-car balancing machines may be either mechanical or electronic, but they are not computerized. Electronic balancers have special lights that flash to indicate weight placement.

  EXAMPLE:

FIGURE 11


Vibration pickup
Strobe light
Spinner
ELECTRONIC
Mechanical balancing instrument
Wheel adapter
Wheel spinner
MECHANICAL

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DIAGNOSING TIRE AND ALIGNMENT PROBLEMS

Problems associated with a vehicle's front-end alignment or tires must be properly diagnosed and corrected for the vehicle to perform at its best. Don't mix different types of tires on the same car. Differences in braking, steering, and handling may make driving the car difficult. Good tires and correct alignment can help provide good stability and insure passenger safety and comfort.

TIRE WEAR PATTERNS

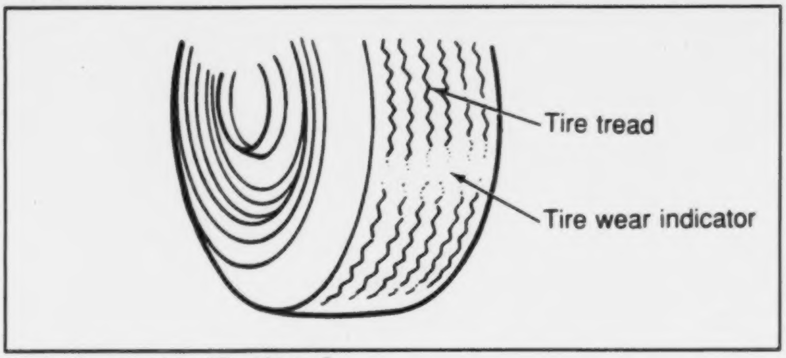
Analyzing the different wear patterns on tires is only one clue that the steering and suspension technician can use to diagnose wheel alignment problems. Wear patterns are, however, an important indication of certain conditions. Wear patterns can give information about tire inflation, toe setting, caster setting, camber setting, tire and wheel assembly service, and general information about how the vehicle is driven.

Table 1 shows various wear patterns and what causes them. Study the illustrations in the table closely. Find those patterns that are related to improper tire inflation, incorrect alignment angles, improper wheel balance, and excessive runout.

Tire wear patterns and test drive findings can often help the technician diagnose tire and alignment problems. For instance, if the vehicle pulls to the left when driven, and if the inner and outer shoulders of the left wheel are excessively worn, the probable cause of the pull is that the left wheel is underinflated.

The tire wear pattern shown in Figure 1 on the next page indicates that the tread is worn and the tire should be replaced. Tires are purposely constructed to show narrow bands of smooth surface across the tread when tread wear reaches a point where tire replacement is necessary. These bands are called *tread wear indicators*.

FIGURE 1



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ALIGNMENT ANGLES

Understanding alignment angles is necessary when diagnosing tire and alignment problems. The steering and suspension technician must know how incorrect caster, camber, and toe affect the control of the vehicle. The technician must also understand how different types of tire wear patterns are caused by incorrect alignment settings.

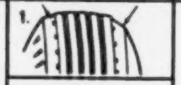
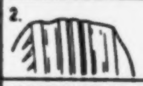
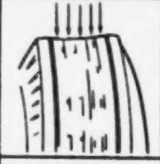
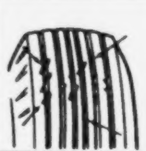
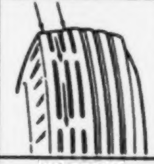
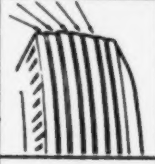
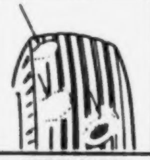
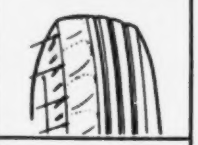
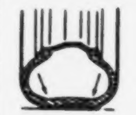
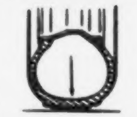
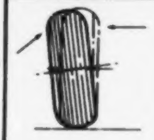
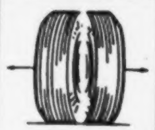
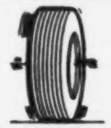
Toe

Toe is one of the most important of the wheel alignment settings and is adjustable on every vehicle. It is, perhaps, the worst tire-wearing angle. As you recall, toe is the amount tires are pointed toward or away from each other. *Toe-in* is the term used when the front of the wheels point inward or toward each other; *toe-out* is the term used when they point outward or away from each other. Because changes in the camber angle can affect the toe setting, toe is always adjusted last. Toe is always adjustable on a vehicle's front wheels, and sometimes it is adjustable on the rear wheels of front-wheel or four-wheel drive vehicles.

For the front wheels to roll parallel, toe must be adjusted to the manufacturer's specs. If a vehicle carries heavy loads over an extended time, the toe should be adjusted while the vehicle is under that load.

TABLE 1

TIRE WEAR PATTERNS

CONDITION	RAPID WEAR AT SHOULDERS	RAPID WEAR AT CENTER	CRACKED TREADS	WEAR ON ONE SIDE	FEATHERED EDGE	BALD SPOTS	SCALLOPED WEAR
EFFECT	1.  2. 						
CAUSE	UNDER-INFLATION OR LACK OF ROTATION	OVER-INFLATION OR LACK OF ROTATION	UNDER-INFLATION OR EXCESSIVE SPEED*	EXCESSIVE CAMBER	INCORRECT TOE	UNBALANCED WHEEL	LACK OF ROTATION OF TIRES OR WORN OR OUT-OF-ALIGNMENT SUSPENSION
						 OR TIRE DEFECT*	
CORRECTION	ADJUST PRESSURE TO SPECIFICATIONS WHEN TIRES ARE COOL ROTATE TIRES			ADJUST CAMBER TO SPECIFICATIONS	ADJUST TOE-IN TO SPECIFICATIONS	DYNAMIC OR STATIC BALANCE WHEELS	ROTATE TIRES AND INSPECT SUSPENSION

*HAVE TIRE INSPECTED FOR FURTHER USE.

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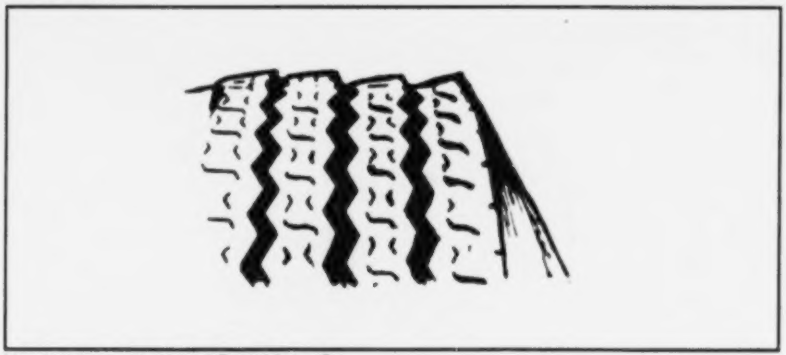
Incorrect toe settings can cause the vehicle to wander, shimmy, or steer hard and cause tire wear. Toe that is not excessive can cause a vehicle to wander. Excessive toe-in will cause the vehicle not only to wander but also to shimmy, especially at higher speeds. Excessive toe-out can cause the vehicle to be difficult to steer. Toe-out that is not excessive may not cause any steering problems. However, it does cause tire wear. Incorrect toe settings can cause tire edges to wear in a feather pattern, as shown in Figure 2.

FIGURE 2



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Tire edges worn smooth can be an indication of incorrect toe. Improper camber adjustment can also cause this type of wear pattern. If the toe setting is the cause, both tires on that axle will show this wear pattern. If there is too much toe-in, the wear will be on the outer tread edges; if there is too much toe-out, the wear will be on the inner tread edges. Incorrect toe settings can cause the edges to wear in a feather pattern, as shown in Figure 2. If camber setting is the cause, feathering will not appear. It is most likely that only one wheel has an excessive camber setting; therefore, only one tire will have a smooth outer or inner edge.

Camber

Camber is the tilt of the top of the tire and wheel assembly inward or outward when compared to a vertical line extending from the center of the bottom of the assembly. Inward tilt is called *negative camber*. Outward tilt is called *positive camber*.

Tire wear and vehicle stability are affected by camber. It is important to remember that improper camber may be the result of either an incorrect adjustment or a bent or damaged suspension system component. Camber is adjustable on most vehicle models, but not all. Since incorrect camber can indicate component damage, camber should be checked against manufacturer's specifications even if it is not adjustable. The camber setting specified by the vehicle manufacturer is the camber angle that will offer the best tire wear, directional stability, and vehicle control. Since camber adjustments can affect other settings such as toe, camber should always be checked first.

Directional stability is maintained by correct camber setting. Incorrect camber can cause a vehicle to wander or pull. Put more simply, the vehicle will pull to the side having the most positive camber. If camber angle is incorrect, it will wear the outside or inside edge of the tread.

Excessive camber also causes tires to wear on one side. (See Table 1.) This wear on the tire edge, called *shoulder wear*, can be on either the inner or outer side of the tire, depending on whether camber is positive or negative. If there is excessive negative camber, the inside shoulder will show wear; if there is excessive positive camber, the outside shoulder will show wear. Improper camber setting, if not corrected, can cause rapid tire wear, decreasing the service life of the tires.

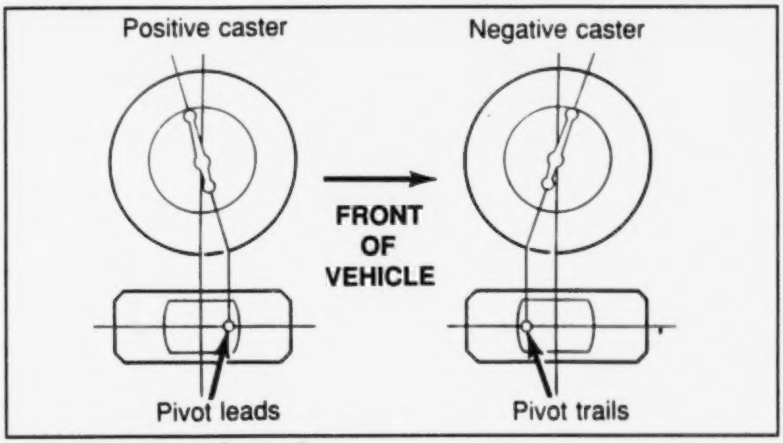
Caster

Normally, caster does not affect tire wear, but it does affect a vehicle's steering. The caster angle is the angle between vertical and a line running through the centers of the upper and lower pivot points of the steering support when viewed from the side of the vehicle. It, too, can be either positive or negative. With *positive caster*, the top of the line through the pivot points tilts toward the rear of the vehicle. With *negative caster*, the top of this line tilts forward.

As with camber, caster may or may not be adjustable. However, it should always be checked.

Caster helps the vehicle maintain a straight ahead direction with little steering effort, helps the wheels return to a straight ahead position after turning, and helps offset pull caused by road crown. The point of load of a vehicle is ahead of the center of the wheel if the caster is positive, as shown in Figure 3 below. In this situation, the point of load "leads" the rest of the wheel, or the wheel "trails" the point of load. This trailing effect is what provides the vehicle with directional stability. The vehicle will move straight ahead unless the driver steers it to the left or right. Conversely, if caster is negative, the point of load is behind the center of the wheel, and the wheel must be "pushed" by the load as illustrated in Figure 3. Here the direction of the wheel is less stable, and the wheel can, to some extent, turn to either the right or left.

FIGURE 3



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If caster of the front wheels is different, the vehicle will pull to one side. The direction to which it pulls depends on the particular caster of each wheel. The vehicle will pull to the side with the *least* amount of positive caster. For example, if the right front wheel has a caster reading of 1° and the left has a reading of ½°, the vehicle will pull to the left. The same rule is true with negative caster. If the right wheel has a reading of –½° and the left has a reading of –1°, the vehicle will pull to the left; a reading of –1° is less positive than –½°.

The characteristics of negative and positive caster differ. Each has certain advantages and disadvantages. These are listed in Table 2 below.

TABLE 2: **Differences between negative and positive caster** *

Positive caster	Negative caster
Tends to make front wheels toe in	Tends to make front wheels toe out
Creates trailing effect which aids directional stability	Creates pushing effect that does not aid directional stability
Makes vehicle tend to lean out on turns	Makes vehicle tend to lean in on turns
Can, if excessive, cause low-speed shimmy and hard steering	Can, if excessive, cause instability at high speeds, steering wander and weave, and easier steering at low speeds
Causes road shock to be transmitted directly through the suspension	Causes road shock to be deflected from the suspension

From Table 2, you can see that both positive and negative caster can be beneficial. To decide whether a vehicle's wheels should have positive or negative caster, the designer must consider several factors. For instance, the designer must consider whether the vehicle has power or manual steering. Positive caster is often used with vehicles having power steering. Negative caster reduces steering effort and is commonly used with vehicles having manual steering systems.

As with toe and camber, many things can affect caster. Increased weight in the rear of the vehicle can cause the caster to become more positive. This, then, can make the vehicle exhibit symptoms of excessive positive caster. There are many factors that must be considered when diagnosing wheel alignment problems.

DIAGNOSING WHEEL BALANCE AND RUNOUT PROBLEMS

Vehicle vibration due to wheel tramp or wobble and some types of tire wear can be caused by either tire and wheel assemblies that are out-of-balance or those that have excessive runout. Because runout and imbalance can cause similar conditions, correctly diagnosing the cause of a problem involving one or the other can often be difficult.

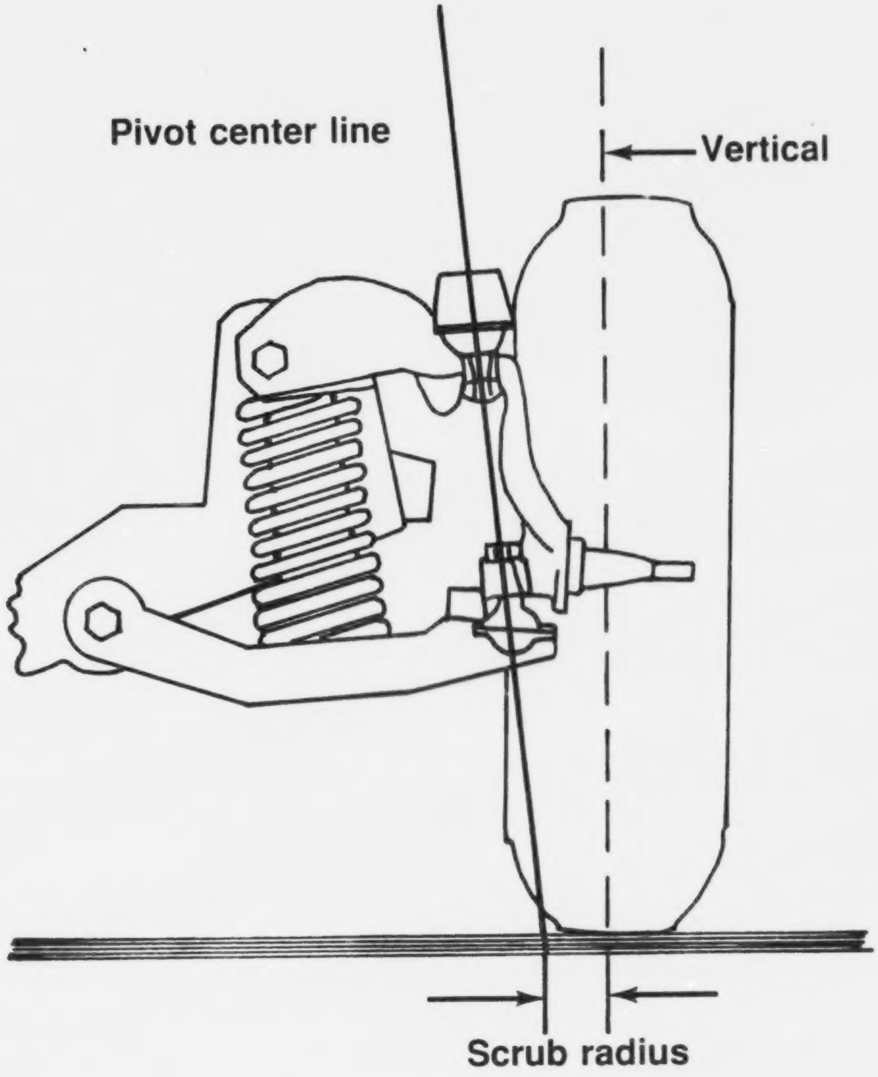
Any pre-alignment inspection should begin with checking such things as tires, including condition, wear patterns, proper inflation, etc., and should include a thorough inspection of wheel bearings and all steering and suspension components. If this type of inspection has been done and all necessary repairs and adjustments have been made, any remaining problems are likely to be caused by wheel imbalance, excessive runout, or misalignment.

The speed at which the vehicle is driven when vibration occurs gives a clue to the cause. For instance, vibration noticed only at speeds below 40 miles per hour is most likely caused by excessive lateral (axial) runout. Vibration occurring at speeds higher than 40 miles per hour—highway driving—is typically caused by wheel imbalance, excessive runout, or faulty tires. With this information, you can see the importance of inspecting and test driving the vehicle when diagnosing wheel balance or runout problems.

In some situations, types of vehicle vibration or roughness or types of tire wear patterns can indicate whether a tire and wheel assembly is statically unbalanced or dynamically unbalanced. A shimmy that can be felt only when driving between certain speeds but disappears at speeds above or below is a result of dynamic imbalance. Wheel tramp that tends to worsen as speed increases is a result of static imbalance. Another indication of tire and wheel imbalance is cupping on the tire tread.

Diagnosing vibration can be taken a step further. Vibration felt in the vehicle's seat is a result of out-of-balance rear wheels or rear suspension system problems. Vibration felt in the steering wheel can be a result of front wheel and/or balance runout problems.

Scrub Radius


Pivot center line
Vertical
Scrub radius

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ACTIVITY SHEET 1

PERFORM PRE-ALIGNMENT INSPECTIONS

V

NAME ______________________________ SCORE ______

Answer general questions about pre-alignment inspections.

INTRODUCTION

To become certified as a steering and suspension technician, you must pass a test on the steering and suspension systems compiled by the National Institute for Automotive Service Excellence. The certification test covers all aspects of the vehicle's steering and suspension systems. This activity sheet only contains questions about pre-alignment inspections, but the questions are realistic and are similar in content and style to those found on the actual ASE certification test.

DIRECTIONS

Read each of the following study questions twice. The second time you may notice a key word you overlooked the first time. Every word in a question is important and may provide a clue to the right answer. Select the answer that is *most* correct and write its letter in the answer blank.

After you have completed this activity sheet, get together with a group of your classmates and use the answer key to check your answers. Discuss the questions and their correct answers, paying particular attention to those that were answered incorrectly. Review any information you do not understand.

______1. Technician A says excessive axle or hub runout can cause wheel tramp or wobble. Technician B says that it can cause wheel tramp or wobble only if the tire and wheel assembly is out of balance. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______2. Technicians A and B are discussing balancing wheels. Technician A says off-car balancing machines may be able to balance wheels both statically and dynamically. Technician B says bubble-type balancing machines are used only to dynamically balance wheels. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______3. Technician A says vibration that worsens as vehicle speed increases can be an indication of alignment problems. Technician B says vibration occurring only at speeds higher than 40 miles per hour is most likely to be caused by wheel imbalance. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______4. Technician A says the old balance weights are left on the wheel during balancing, and additional weights are added if necessary. Technician B agrees, but says weights are not added unless one or more is missing. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______5. Technician A says wheel tramp can be caused by a wheel that is out of balance dynamically. Technician B says wheel wobble or shimmy can be caused by a wheel that is out of balance statically. Who is correct?

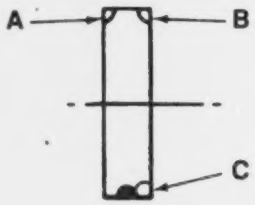
A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______6. Technicians A and B are discussing the following caster and camber readings of a vehicle's front wheels. Technician A says the vehicle probably pulls to the right when driven. Technician B says it probably pulls to the left. Who is correct?

	Camber	Caster
Left	1¼°	½°
Right	1¾°	½°

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______7. The illustration below shows the location of a heavy spot on a tire and wheel assembly. In order to properly static balance the assembly, at what point(s) should the weights be placed?



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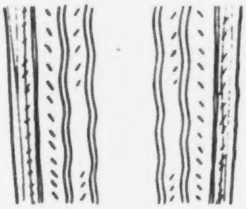
A. Points A and C
B. Points B and C
C. Points A and B
D. Points A and C

______8. Study the tire wear pattern illustrated below. What is indicated by this wear pattern?



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A. The wheel has excessive negative caster
B. The tire has excessive radial runout
C. The wheels have incorrect toe setting
D. The tire is worn and should be replaced

______9. Technicians A and B are discussing caster. Technician A says a vehicle with positive caster tends to lean out on turns. Technician B says a vehicle with negative caster tends to lean in on turns. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______10. Technicians A and B are discussing the caster and camber readings shown below. Technician A says the vehicle probably pulls to the left when driven. Technician B says since a difference in caster settings has a greater effect on vehicle direction than a difference in camber settings, the vehicle probably will not pull either right or left. Who is correct?

	Camber	Caster
Left	1½°	½°
Right	1¾°	0°

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

ACTIVITY ANSWERS

PERFORM PRE-ALIGNMENT INSPECTIONS V

ACTIVITY SHEET 1

1. A
2. A
3. B
4. D
5. D
6. A
7. C
8. D
9. C
10. D

ASSIGNMENT SHEET 1

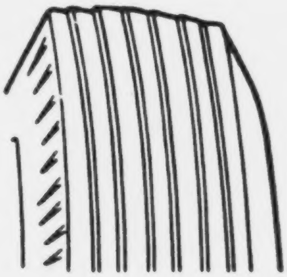
PERFORM PRE-ALIGNMENT INSPECTIONS

NAME ______________________ SCORE ________

OBJECTIVE 5 **Analyze tire wear patterns.**

INTRODUCTION Inspecting tires and analyzing any apparent wear pattern is an important part of the steering and suspension technician's job. Since tire wear patterns can indicate tire conditions and alignment problems, determining the cause of such patterns can help in diagnosing tire and alignment problems.

DIRECTIONS Read Supplement 1, Diagnosing Tire and Alignment Problems, and study the following illustrations of various tire wear patterns. Write the probable causes of the wear patterns in the blanks.



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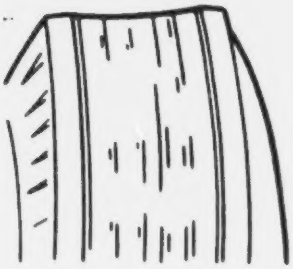
1. ______________________________



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2. ______________________________

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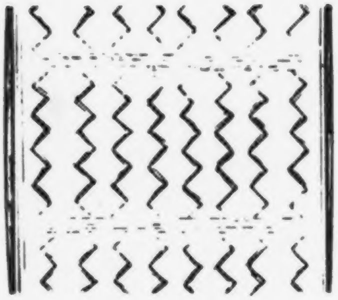
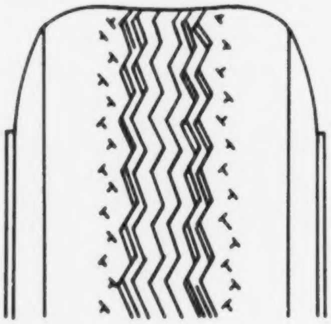


3. ______________________________



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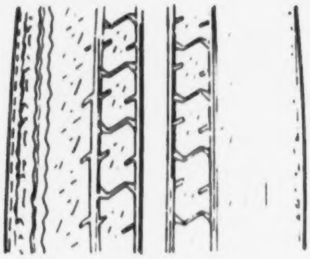

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5. ______________________________

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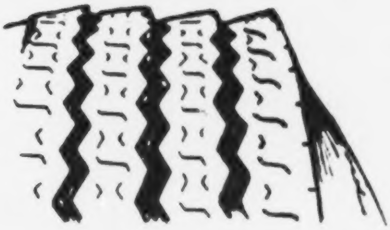

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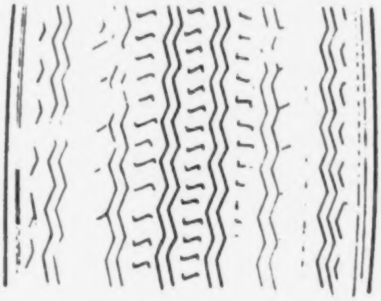
6. ______________________________



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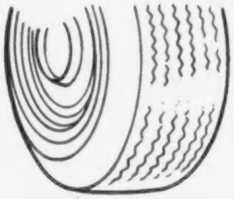
7. ______________________________



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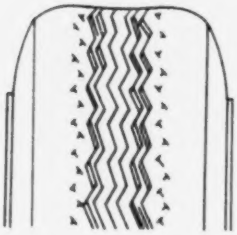
8. ______________________________



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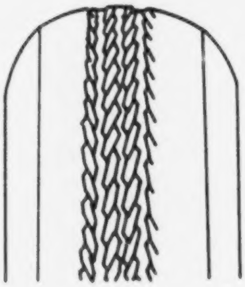
9. ______________________________________



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10. ______________________________________

ASSIGNMENT SHEET 2

PERFORM PRE-ALIGNMENT INSPECTIONS

V

NAME ______________________________ SCORE ______

OBJECTIVE 6

Diagnose wheel balance and runout problems.

INTRODUCTION

Determining the cause of specific problems is an important part of the steering and suspension technician's job. Accurate diagnosis insures that the problem can be corrected properly in a timely manner.

Problems caused by certain runout and wheel balance conditions are often similar. Therefore, it is important for the technician to determine which problems are caused by excessive runout and which are caused by improper wheel balance.

PART A DIRECTIONS

Read each of the following questions carefully. Then, using your knowledge of wheel balance and runout, information from Supplement 2, Diagnosing Wheel Balance and Runout Problems, and service manual diagnostic charts, select the answer that is *most* correct. Write the correct letters in the blanks.

______1. A customer brings his vehicle to your shop. He says he had new tires put on a few days ago, and he now notices vibration when driving on the highway. What is the **most** likely cause of this type of vibration?

A. Excessive tire radial runout
B. Improper tire size
C. Improper tire inflation
D. Tire and wheel assemblies not properly balanced

______2. You test drive a vehicle and find that it vibrates when travelling at least 50 miles per hour. Which of the following should you check first?

A. Tire and wheel runout
B. Wheel alignment adjustment
C. Tire and wheel assembly balance
D. Shock absorber condition

_______3. A customer brings her light-duty pickup to you for service. She says that she just had the wheels balanced, but at low speeds she still feels vibration in the steering wheel. Which of the following should you check first?

A. Front suspension system alignment
B. Steering system component looseness
C. Hub runout
D. Axial runout

_______4. A customer brings in his front-wheel drive car and complains that it vibrates when he drives 55 miles per hour. He says the vibration doesn't get worse at higher speeds, and it disappears when traveling at speeds lower than 55 miles per hour. Which of the following is the **most** likely cause of this problem?

A. Axial runout
B. Dynamic imbalance
C. Loose front suspension system components
D. Improper tire inflation

_______5. A rear-wheel drive pickup has been brought to your shop for service, and the owner has asked to have the tire and wheel assemblies checked. When you inspect the tires for wear, you find that one tire has excessive cupping. However, you feel no excessive shimmy during your test drive. What could be the cause of the cupping?

A. Static imbalance
B. Dynamic imbalance
C. Excessive tire lateral runout
D. Hub runout

_______6. When you test drive a vehicle brought to your shop, you find that it wanders. Which of the following is the **most** likely cause?

A. Dynamic imbalance
B. Excessive wheel radial runout
C. Loose steering system components
D. Excessive wheel axial runout

PART B DIRECTIONS

Read the following situations and questions carefully then write your answers in the blanks provided.

1. A customer brings in his vehicle to have the wheels balanced. He says he can feel vibration when driving at speeds between 15 and 30 miles per hour. While visiting with the customer, you learn that the car's odometer reads 30,000 miles, and the original tires are on the vehicle. Is this vibration most likely due to wheel imbalance?

2. To correct a vibration problem, the technician checked tire and wheel lateral and radial runout with the wheels off of the vehicle and found the readings to be within specifications. She then balanced the wheels and re-installed them on the vehicle. She again test drove the vehicle and found that wheel tramp could still be noticed. What could be causing this problem?

3. A customer brings in an older model car to your shop and complains that the vehicle vibrates when driving at speeds below 35 miles per hour. If the wheels are balanced both statically and dynamically, what could be the problem?

4. When you test drive a vehicle brought to your shop for service, you notice wheel tramp that seems to worsen as you drive faster. What could cause this problem?

ASSIGNMENT SHEET 3

PERFORM PRE-ALIGNMENT INSPECTIONS

NAME ______________________________ SCORE ________

OBJECTIVE 7 **Diagnose alignment problems.**

INTRODUCTION

An important factor in vehicle handling and operation is wheel alignment. Wheels must be in correct alignment so the vehicle will steer and track properly. Therefore, an important part of a steering and suspension technician's job is to correctly diagnose alignment problems.

Since many steering and suspension problems are similar to alignment problems, it is important that the technician consider this when test driving a vehicle. A thorough inspection of the steering system and the suspension system should be performed, and any needed repairs or adjustments should be made before wheel alignment is performed. After correcting any of these problems, the technician can then concentrate on other conditions that are the result of incorrect alignment settings.

PART A DIRECTIONS

Read each of the following situations. Then, using your knowledge of alignment diagnosis and the information found in Student Supplement 1, Diagnosing Tire and Alignment Problems, and in service manuals, select the correct answers for the following questions. Write the correct letters in the blanks.

______1. A customer brings in his 1987 Dodge Dynasty to your shop to have the wheels aligned. When you inspect the tires, you find the inside shoulders of both tires show excessive wear. What alignment problem would **most** likely cause this condition?

A. Excessive positive camber of both wheels
B. Excessive negative caster of both wheels
C. Excessive toe-out
D. Excessive toe-in

______2. While checking the camber angles of a vehicle's front wheels, you find the camber angle of the left front wheel is 1½° and the camber of the right front wheel is ¾°. What could these camber settings cause?

A. Vehicle pull to the left
B. Vehicle pull to the right
C. Excessive wear on the outer side of the right front tire
D. Excessive wear on the inner side of the left front tire

______3. Technicians A and B are discussing the tire wear patterns on a vehicle in their shop. The front tires show excessive wear on their outer shoulders. Technician A says this could be caused by too much toe-out. Technician B says this could be caused by excessive positive camber of both wheels, although it is very unlikely. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______4. A customer brings in her late model car to your shop for wheel alignment, complaining of vehicle wander. The car has recently had its steering and suspension systems inspected. Which of the following alignment problems could cause the car to wander?

A. Excessive negative caster of both front wheels
B. Excessive negative camber of both front wheels
C. Excessive positive caster of both front wheels
D. Either B or C

______5. While inspecting a vehicle's tires, you find the inner and outer shoulders of the left front tire show extreme wear. When the vehicle owner brought the vehicle to you, he complained that the vehicle seemed to shimmy at low speeds. What should you first suspect to be the cause of the wear pattern on the left front tire?

A. Excessive positive camber of the left front wheel
B. Overinflation of the left front wheel
C. Underinflation of the left front wheel
D. Incorrect toe setting

______6. While checking the alignment angles of a vehicle's wheels, you find that the caster reading of the right front wheel is -1½° and the caster reading of the left front wheel is 1½°. You check the service manual and find that 1° is the specified setting. How could these incorrect caster settings affect the vehicle?

A. Vehicle pull to the left
B. Vehicle shimmy at high speeds
C. Vehicle pull to the right
D. Excessive wear of the left front tire

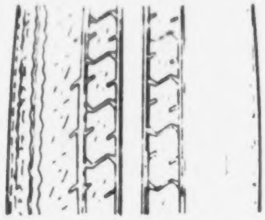
______7. You checked the toe setting of a vehicle brought to your shop and found that toe-in exceeded manufacturer's specifications. Which of the following problems could this incorrect toe setting cause?

A. Vehicle pull to right
B. Vehicle pull to left
C. Tire wear on the outer side of both front tires
D. Both A and C

______8. While inspecting the tires of a compact car, you notice the right front tire looks really worn on the outside shoulder. What could cause this type of wear?

A. Excessive positive caster
B. Excessive positive camber
C. Excessive negative caster
D. Excessive negative camber

______9. A 1987 Chevrolet Cavalier has been brought to your shop for wheel alignment service. You first inspect the tires and find the wear pattern shown below. If this is the left front tire, which of the following is the **most** likely cause of this type of wear?



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- A. Excessive negative camber
- B. Excessive positive caster
- C. Excessive positive camber
- D. Excessive toe-out

______10. When you test drive a vehicle, you notice that it pulls to the left. Which of the following conditions could cause this?

- A. Positive caster of the right wheel and excessive negative caster of the left wheel
- B. Positive camber of the right wheel and excessive negative caster of the left wheel
- C. Positive caster of the left wheel and excessive negative caster of the right wheel
- D. Both B and C

______11. You are checking the alignment angles of a vehicle you are servicing. You find the camber angle of both wheels is ½°, the caster angle of the left front wheel is –½°, and the caster angle of the right front wheel is ¾°. Which of the following driving tendencies does the vehicle **most** likely exhibit?

- A. Vehicle pull to the left
- B. Vehicle pull to the right
- C. Vehicle shimmy at high speeds
- D. Vehicle vibration when turning right

_____12. While test driving a 1988 Ford Taurus, you notice the vehicle seems to pull to the right while driving on various types of road surfaces. After you complete the test drive, you check the tires and find they are inflated properly. Which of the following could cause the vehicle to pull to the right?

A. Excessive positive caster of the left front wheel
B. Excessive negative caster of the right front wheel
C. Excessive negative camber of the right front wheel
D. Both A and B

_____13. Technicians A and B are discussing the camber and caster readings shown below. Technician A says the vehicle probably pulls to the left because caster is more positive on the left side. Technician B says the vehicle probably pulls to the right because the camber is more positive on the right side. Who is correct?

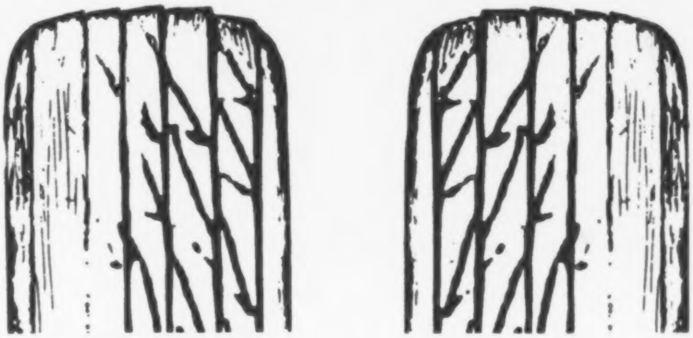
	Camber	Caster
Left	–½°	0°
Right	0°	–½°

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____14. Technicians A and B are inspecting the tires on a vehicle a customer brought to their shop. The right front tire is worn on the inside shoulder, and the left front tire has normal wear. The customer had complained the vehicle seemed to pull to the left. Technician A says the left front wheel probably has excessive positive camber. Technician B says the right front wheel probably has excessive negative camber. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____15. A customer brings her vehicle to your shop and asks to have the front wheels aligned. You inspect the tires and find the wear pattern shown below. Which of the following is the **most** likely cause of this type of wear?



A. Excessive toe-in
B. Excessive positive caster of both wheels
C. Excessive toe-out
D. None of the above

PART B

Study each of the following camber and caster readings. In the blanks below each set of readings, write whether the vehicle will pull right, pull left, or maintain a straight-ahead position when driven and explain why.

1.

	Camber	Caster
Left	1°	½°
Right	½°	½°

____

____

2.

	Camber	Caster
Left	¾°	0°
Right	¾°	½°

____

____

3.

	Camber	Caster
Left	−½°	0°
Right	0°	−½°

4. Which of the three camber and caster readings listed in questions 1-3 would have the most severe effect on a vehicle? Why?

ASSIGNMENT ANSWERS

PERFORM PRE-ALIGNMENT INSPECTIONS

V

ASSIGNMENT SHEET 1

1. Incorrect toe
2. Overinflation
3. Excessive camber
4. Underinflation
5. Excessive camber or incorrect toe
6. Incorrect toe
7. Underinflation
8. Overinflation
9. Overinflation
10. Underinflation

ASSIGNMENT SHEET 2

PART A

1. D
2. C
3. B
4. B
5. A
6. C

PART B

1. No
2. Excessive hub or axle runout
3. Lateral runout
4. Static imbalance

ASSIGNMENT SHEET 3

PART A

1. C
2. B
3. B
4. A
5. C
6. C
7. C
8. B
9. C
10. A
11. A
12. D
13. B
14. B
15. A

PART B

1. Pull left; left side has more positive camber
2. Pull left; left side has least positive caster
3. Pull right; right side has most positive camber and least positive caster
4. The camber and caster settings shown in Number 3 would have the greatest effects; both camber and caster in this situation could cause the vehicle to pull right

JOB SHEET 1

PERFORM PRE-ALIGNMENT INSPECTIONS

V

OBJECTIVE 8A

Measure axle and hub runout.

INTRODUCTION

Just as excessive tire or wheel runout can cause abnormal tire wear and vehicle vibration, so can axle or hub runout. If tire and wheel runout measured with the wheel assembly mounted on the vehicle is not within manufacturer's specifications, and runout measured while the wheel assembly is off the vehicle is within specifications, then the excessive runout is not caused by the tire or wheel. Another runout check—measuring axle and hub runout—must be done.

To measure hub runout, lateral runout of the rotor hub (on wheels with disc brakes) or of the axle flange (on wheels with drum brakes) must be checked. Axle runout is a radial runout measurement and is checked by measuring the runout of the wheel studs.

Since wheel tramp or wobble can be caused by excessive lateral or radial runout, whether or not the wheels are balanced, check tire and wheel balance before checking runout. By doing so, any corrective action, such as replacing tires or bent wheel rims, can be done before balancing the wheel assemblies. Wheel balancing should remedy any other vibration problems.

Although the procedure for measuring axle and hub runout is not complicated, there are some guidelines and precautions that should be followed whenever you perform this procedure. These are listed below.

Guidelines:

- Refer to the vehicle manufacturer's service manual for proper jack and jack-stand placement.
- Make sure the hub/axle assembly is clean before taking a measurement with the dial indicator.
- After measuring tire and wheel runout, remove the tire and wheel and measure runout. Compare your findings to manufacturer's specifications and diagnose the problem.

- Refer to the vehicle manufacturer's service manual for runout specifications. If the measurements are not within specifications, the axle, bearing, or axle housing may be damaged or the rotor or hub may need to be replaced. If any of these are replaced, the tire and wheel assembly balance must be rechecked.

EQUIPMENT AND MATERIALS

- Vehicle
- Appropriate service manual
- Wheel Alignment Check Sheet
- Eye protection
- Jack and jack stands
- Dial indicator with magnetic or C-clamp base
- Pencil and paper
- Basic hand tool set
- Torque wrench
- Wire brush

CAUTION

Always check the procedure in the vehicle's service manual before beginning any service or repair.

PROCEDURE

Measure axle and hub runout

1. Loosen the lug nuts one turn.

2. Raise the vehicle and support it safely with jack stands.

3. Remove the tire and wheel assembly.

4. Use a wire brush to clean the hub and wheel studs.

5. Inspect the hub to see that it is clean and free of dents or nicks.

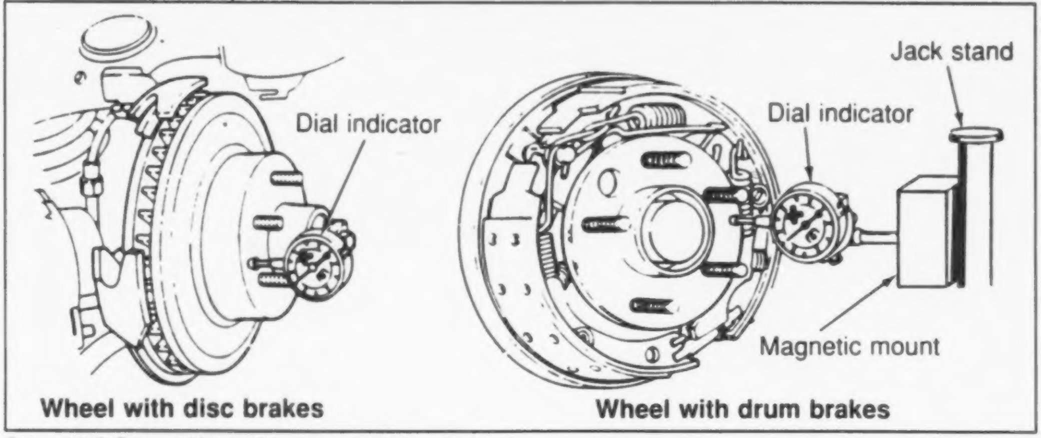
   NOTE: Small nicks or dents can cause the runout reading to be misleading, and this should be considered when measuring hub runout.

6. Adjust the bearings to zero end play.

7. Position the dial indicator so the plunger is on a flat surface of the rotor hub (for disc brakes) or axle flange (for drum brakes), outside the wheel studs. (Figure 1)

   NOTE: Be sure the base of the dial indicator is not mounted on the surface to be rotated.

FIGURE 1



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8. Slowly rotate the rotor or axle flange by hand and find the low spot.

9. Zero the dial indicator.

10. Put a slight inward pressure on the axle flange and slowly rotate the rotor or axle flange by hand through one complete turn; record the reading.

11. Compare the reading with the vehicle manufacturer's specifications; if the reading is not within specifications, the rotor, hub, or axle must be replaced. On hubless rotors, install a minimum of three lug nuts and tighten to specs.

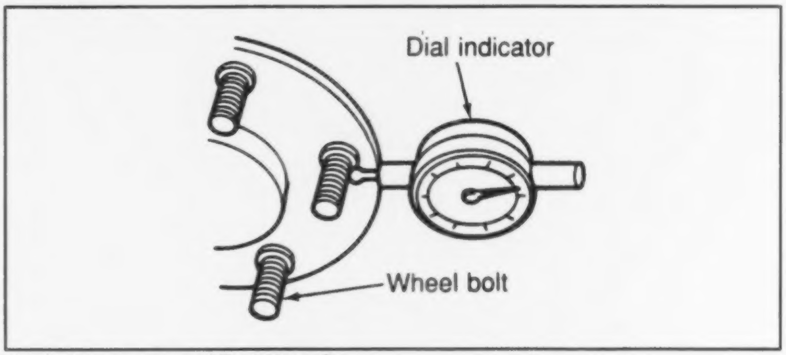
    NOTE: The axle flange is part of the axle. Therefore, the entire axle must be replaced if axle flange runout is excessive. Some cars with disc brakes have a rotor that is separate from the hub; if this is the case, either the hub or the rotor may need to be replaced.

12. Remove the dial indicator and set it aside.

13. Inspect the wheel studs to see that none are damaged or bent; if any are bent or damaged, they must be replaced.

14. Position the dial indicator so the plunger can touch the wheel studs as close to hub or axle flange as possible. (Figure 2)

FIGURE 2



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15. Slowly rotate the rotor or axle flange by hand and find the wheel stud furthest in.

16. Zero the dial indicator.

    NOTE: Some manufacturers recommend zeroing the dial indicator at a point between the wheel stud furthest in and the wheel stud furthest out; the difference between the readings at these two studs would be the total runout.

17. Slowly rotate the rotor or axle flange by hand, recording the reading at each stud, through one complete turn.

18. Compare the reading with the vehicle manufacturer's specifications; if the reading is not within specifications, the axle or wheel studs may need to be replaced.

    NOTE: Excessive axle runout is most often the result of bent wheel studs. However, an excessive reading could be the result of a bent axle.

19. Remove the dial indicator.

20. Install the tire and wheel assembly.

21. Lower the vehicle and torque the lug nuts to specifications.

22. Clean work area and return equipment and materials to proper storage or proceed to the next job sheet as directed by your instructor.

JOB SHEET 2

PERFORM PRE-ALIGNMENT INSPECTIONS

V

OBJECTIVE 8B

Balance wheels.

INTRODUCTION

When the tire and wheel assemblies have both static and dynamic balance, the vehicle drives smoother at varying speeds and has greater stability. Unbalanced wheels not only contribute to a rougher ride but if severe, can cause damage to steering and suspension components. Additionally, unbalanced wheels can cause abnormal tire wear, decreasing the service life of the tires.

Some vehicle manufacturers recommend checking wheel balance every 10,000 miles or once a year. This interval varies with other vehicle or tire manufacturers. Wheels should be balanced after a tire has been repaired, if a wheel weight has been lost, after new tires or wheel rims are installed, and before wheel alignment is checked and adjusted.

Wheel alignment problems and wheel balance problems may be evidenced by similar conditions. If this occurs, a vehicle's tire and wheel assemblies should be balanced before the alignment is checked. By doing so, it is likely that problems the driver thinks are related to alignment can be corrected by balancing the vehicle's wheels. Once the wheels are balanced, the steering and suspension technician can more accurately diagnose and correct alignment problems.

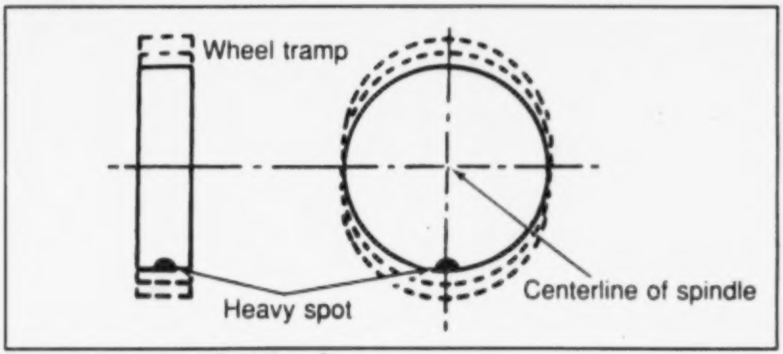
To correct wheel imbalance, special weights are attached to the wheel rim. Applying weights corrects the unequal weight distribution of the tire and wheel assembly. Old weights should not be used. Weights are positioned to counteract heavy spots or areas of the wheel assembly. The technician must use a balancing machine to determine what size weight is needed and the location on the rim where the weight should be placed.

There are two types of balance weights—clip-on weights and tape-on weights. Clip-on weights are specially shaped lead weights with steel clips. These are available in weights ranging from one-half ounce to three and one-half ounces. A special tool is used to attach clip-on weights to the wheel rim. Tape-on weights are used on aluminum or mag wheels or other wheels with nonconventional rims. These weights are available as strips and have an adhesive backing.

Although the weight must be equally distributed to achieve either static or dynamic balance, the placement of the weights is different for each type of balance. In order to properly position balance weights, the steering and suspension technician must first understand static and dynamic balance.

As you will recall, *static* balance is achieved when a tire and wheel assembly has weight equally distributed around its axis of rotation—the wheel spindle. Heavy spots on the tire tread surface can cause a wheel to be out-of-balance statically and can cause hop or wheel tramp, as shown in Figure 1 below.

FIGURE 1



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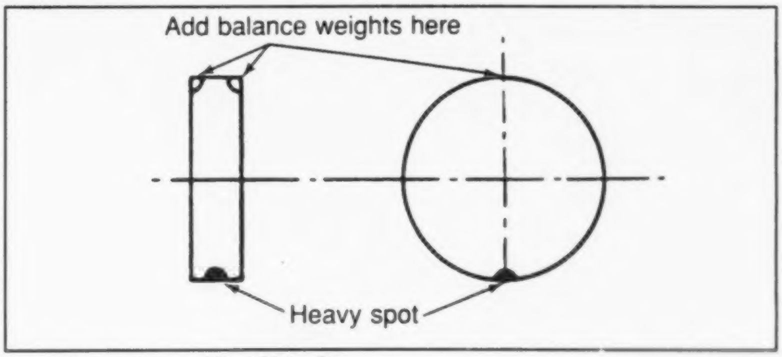
Static balance can be checked with the wheels either on or off the vehicle, depending on the type of balancing machine used. Any of these machines, however, checks the wheel assembly for any heavy spots. Once a heavy spot is located, it is marked, and one or more weights are attached to the wheel rim opposite the mark. Figure 2 below shows the placement of balance weights.

FIGURE 2



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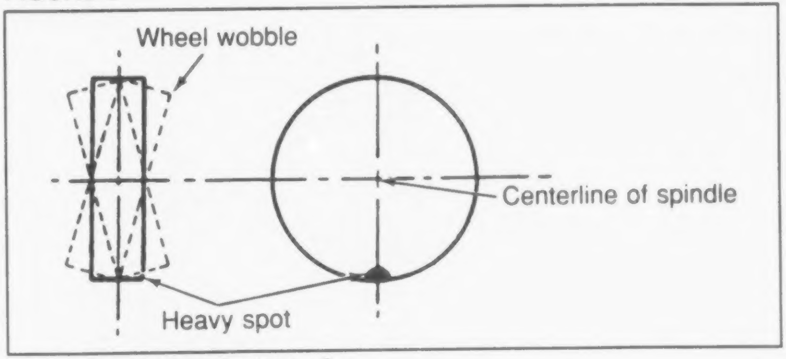
When a tire and wheel assembly has weight equally distributed with respect to the center line of the assembly, it has *dynamic* balance. Dynamic imbalance is caused when a tire has heavy spots on the edge of the tread surface or on the side of the tire. This causes the wheel to wobble, as shown in Figure 3.

FIGURE 3



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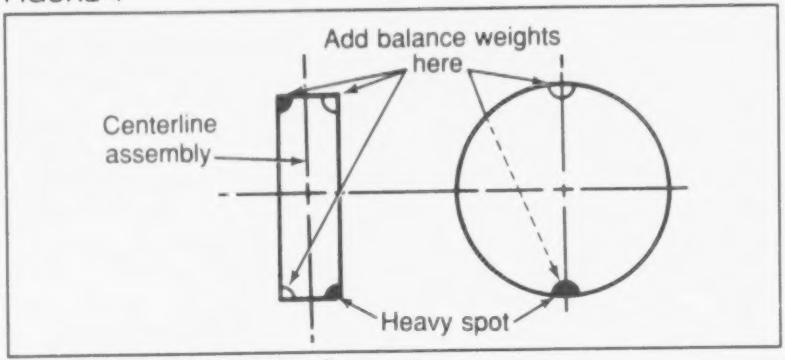
Dynamic balance must be checked after static balance is checked and corrected. On-car or off-car balancing machines may be used; however, with either type, the wheel must be spinning in order to check dynamic balance.

Balancing machines used to check dynamic balance locate heavy spots or areas on the tire and wheel assembly which cause the assembly to be out-of-balance. To balance the assembly, weights are added. One weight is added to the rim opposite the heavy spot, and another weight is added on the opposite side of the rim and 180 degrees from the first weight, as shown in Figure 4 on the next page. Placing weights on opposite edges of the wheel not only balances it dynamically but maintains the wheel's static balance.

FIGURE 4



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All bubble-type balancing machines operate in much the same way. The tire and wheel assembly is removed from the vehicle and is mounted on the bubble balancer. A bubble in the sight glass on the balancer indicates if part of the assembly is heavier than the rest. The bubble will move toward the light side of the wheel. If the bubble is centered, the assembly is statically balanced.

On-car balancing machines, as their name implies, balance a tire and wheel assembly while it is still mounted on the vehicle. These types of machines balance the wheel assembly along with the hub and brake drum or rotor. They may check both static and dynamic balance, or they may check only dynamic balance. Mechanical balancers have a wheel spinner, an adapter for the wheel, and a balancing instrument which is used to determine the amount and placement of weight. On other machines, imbalance may be indicated by an electronic device, usually a light that flashes to indicate where balance weights should be attached. The wheel is spun during the balance check; nondrive wheels are spun by a special wheel spinner, and drive wheels are spun by the vehicle's engine. On-car balancing machines are not computerized.

Most off-car balancing machines, however, are computerized. These balancers check dynamic balance. With most computerized off-car balancing machines, information such as rim distance, wheel diameter, and wheel width is entered into the computer. The wheel assembly is then spun to determine imbalance and locate attachment points for balance weights.

The procedures for using different bubble-type balancing machines are similar. However, procedures for using different on-car balancers and off-car balancers vary considerably. The technician must always refer to the balancing machine manufacturer's manual for operating procedures and to the vehicle manufacturer's service manual for specifications and additional guidelines. General guidelines and precautions that should be followed when balancing tire and wheel assemblies are listed below and on the following pages.

Guidelines:

- If a problem exists after balancing, check the tire, wheel, and axle and hub runout and make any needed replacement or repair.

  NOTE: Wheel covers can also cause imbalance.

- Prepare the tire and wheel assembly properly before beginning balancing procedures:
  - Use a wire brush to clean the wheel rim, removing all dirt and grease.

    NOTE: Be careful not to damage custom rims if they are used.

  - Use high-pressure water to clean the tire, removing all dirt, gravel, and rocks from the tire tread area. Allow the assembly to dry.
  - Clean the hub/brake assembly if you are using an on-car balancer.
  - Inflate the tires to specifications.
- After cleaning and preparing the tire and wheel assembly, check the wheel balance. Occasionally these steps alone are sufficient to bring the assembly into balance.
- If the tire and wheel assembly still needs to be balanced, remove the old wheel weights.
- Adjust the wheel bearings to specifications before balancing tire and wheel assemblies with on-car balancing machines.

- If the tire and wheel assembly is to remain on the vehicle during balancing, torque the lug nuts to specifications.

- If the tire and wheel assembly is removed for balancing, use a chalk or marker to index the assembly before removing it from the vehicle.

- If the tire and wheel assembly is removed for balancing, check the wheel center hole to see if any nicks or burrs are present. If any are found, smooth the area with a round mill file.

- Raise and support the vehicle properly when balancing the wheels while mounted on the vehicle. Axles must be supported so they are at approximately the same angle as they are when the vehicle is being driven. Refer to the vehicle manufacturer's instructions for jack and jack-stand placement.

CAUTION

Be sure to follow manufacturer's instructions for raising a vehicle with front-wheel drive. Allowing CV joints to hang at incorrect angles while the wheels are spinning can damage the joints. Since some rear-wheel drive vehicles with independent suspension use similar drive axles, this guideline should be observed when raising the rear of these vehicles. Limited-slip rear ends cannot have one wheel on the ground.

- Use a spinner for on-car balancing only when balancing nondrive wheels. Do not use a spinner on drive wheels—use the engine to spin the wheels.

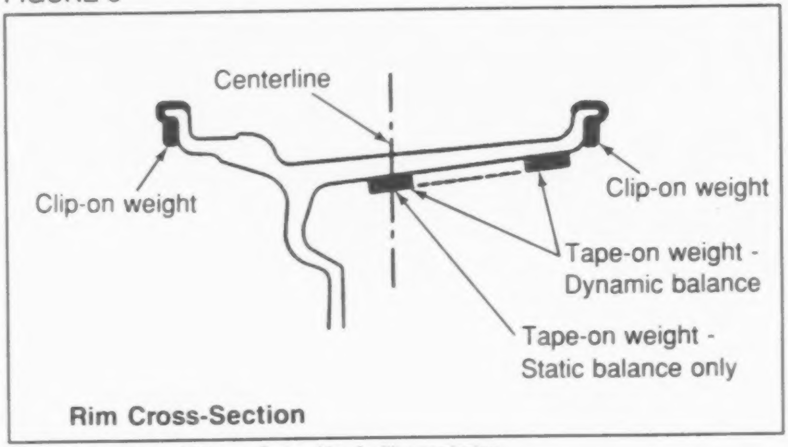
CAUTION

Do not exceed the speed specified by the vehicle manufacturer when using the engine to spin the drive wheels. Exceeding the speed limits may damage the transaxle or differential and may cause personal injury.

- Use the spinner for on-car balancing by using it to correct the speed and then take the spinner away from the tire. Make adjustments while the wheel is rotating on its own rather than when it is being driven.

- Select the correct adapter to fit the wheel to be balanced, if using a mechanical on-car balancing machine. Also be sure that the adapter is securely mounted before spinning the vehicle wheel.
- Always mount the tire and wheel assembly on off-car balancers so that the outer side of the assembly faces either out or up, depending on balancing machine instructions.
- Mount the tire and wheel assembly on off-car computer balancers carefully, making sure the assembly is properly mounted. Do not drop the assembly on the mount or use excessive force, as this could damage the balancing machine.
- Use the locking device, if the machine is so equipped, to secure the bubble-type balancing machine when (1) the wheel is mounted on the machine, (2) weights are installed, and (3) the wheel is removed. At all other times it should remain unlocked.
- Clean aluminum or mag wheels thoroughly, following the vehicle manufacturer's instructions before attaching tape-on wheel weights.
- Divide by two any weight of one-half ounce or more needed to statically balance the wheel. Place one weight equal to this new amount on the inside of the rim and another on the outside of the rim.
- Correctly position the weights on the rim. Attach clip-on weights to the rim flange for either static or dynamic balance. Attach tape-on weights to the wheel rim near drop-center of the rim for static balance; attach them closer to the outer edge of the rim for dynamic balance. Weight placement is shown in Figure 5 on the following page.
- Before positioning tape-on weights, make sure there is no interference with brake calipers, drums, or lines.

FIGURE 5


Centerline
Clip-on weight
Clip-on weight
Tape-on weight - Dynamic balance
Tape-on weight - Static balance only
Rim Cross-Section

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Procedures for using off-car and on-car balancing machines vary greatly; therefore, the procedures outlined in the operator's manual for the specific machine being used to balance wheels must be followed.

EQUIPMENT AND MATERIALS

- Vehicle
- Appropriate service manual
- Balancing machine
- Operating manual for the balancing machine
- Other equipment and materials as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

PERFORM PRE-ALIGNMENT INSPECTIONS

JOB SHEET 1

Measure axle and hub runout.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained the proper equipment and materials.	______	______
2. Prepared the vehicle and work area appropriately.	______	______
3. Measured hub lateral runout following outlined procedures.	______	______
4. Measured axle radial runout following the outlined procedure.	______	______
5. Observed safety rules and precautions.	______	______
6. Completed the service and the Wheel Alignment Check Sheet correctly.	______	______
7. Cleaned the work area and returned equipment and materials to proper storage.	______	______

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

____

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 2

Balance wheels.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. ______

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained the proper equipment and materials.	______	______
2. Prepared the vehicle and work area appropriately.	______	______
3. Prepared the tire and wheel assemblies following the outlined procedure.	______	______
4. Correctly balanced the tire and wheel assemblies using a bubble-type balancing machine.	______	______
5. Correctly balanced the tire and wheel assemblies using an on-car balancing machine.	______	______
6. Correctly balanced tire and wheel assemblies using an off-car balancing machine.	______	______
7. Used tools and equipment correctly.	______	______
8. Observed safety rules and precautions.	______	______
9. Cleaned the work area and returned equipment and materials to proper storage.	______	______

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

WRITTEN TEST

PERFORM PRE-ALIGNMENT INSPECTIONS

V

NAME ______________________________ SCORE ________

OBJECTIVE 1

Select the definitions of terms associated with pre-alignment inspections. Choose the definitions that best define the following terms and write the correct letters in the blanks.

_____1. **dynamic balance**

A. Process of checking and correcting those angles of the steering geometry that are adjustable
B. Condition of the tire and wheel assembly having the weight equally distributed in respect to the center line of the tire and wheel assembly
C. Condition of the tire and wheel assembly having the weight equally distributed around the wheel
D. Process of checking the wheel tramp of a tire

_____2. **scrub radius**

A. Distance between the camber angle and the caster angle
B. Distance between the points where the center line of the tire and true vertical line contact the road surface
C. Distance between the camber angle and a line through the suspension pivot points
D. Distance between the points where the center line of the tire and a line through the suspension pivot points contact the road surface

_____3. **static balance**

A. Process of checking and correcting those angles of the steering geometry that are adjustable
B. Condition of the tire and wheel assembly having the weight equally distributed in respect to the center line of the tire and wheel assembly
C. Condition of a tire and wheel assembly having the weight equally distributed around the wheel
D. Condition of the proper amount of tire surface being in contact with the road surface

_______4. **radial runout**

A. Measurement of the variation of the side surface of an object
B. Measurement of the tread wear of a radial tire
C. Measurement of the variation of an object's circumference or out-of-roundness
D. Measurement of side-to-side motion

_______5. **wheel balancing**

A. Process of checking and correcting those angles of the steering geometry that are adjustable so the vehicle will steer and track properly without producing abnormal tire wear or undesirable steering characteristics
B. Process of locating all tire defects
C. Measuring the surface of a rotating tire and wheel assembly
D. Process of checking and correcting the balance of a tire and wheel assembly so the weight is equally distributed

_______6. **lateral runout**

A. Measurement of the variation of the side surface of an object
B. Measurement of the base variation of a rotating object
C. Measurement of the variation of an object's circumference or out-of-roundness
D. Measurement of the variation in a wheel's speed of rotation

______7. **wheel alignment**

- A. Process of checking and correcting the balance of a tire and wheel assembly so the weight is equally distributed
- B. Process of checking and correcting those angles of the steering and suspension geometry that are adjustable so the weight is equally distributed around the tire and wheel assembly
- C. Process of checking and correcting those angles of the steering geometry that are adjustable so the vehicle will steer and track properly without producing abnormal tire wear or undesirable steering characteristics
- D. Process of checking and correcting tire faults

______8. **runout**

- A. The distance between tire treads
- B. The distance the surface or edge of a rotating part moves in or out during rotation
- C. The straightness of tire prints
- D. The distance the surface of a tire rotates during a turn

______9. **shimmy**

- A. Side to side movement; dynamic imbalance
- B. Side to side movement; static imbalance
- C. Up and down movement; dynamic imbalance
- D. Up and down movement; static imbalance

______10. **wheel tramp**

- A. Up and down out-of-round; static imbalance
- B. Up and down movement; dynamic imbalance
- C. Side to side movement; static imbalance
- D. Up and down out-of-round; dynamic balance

OBJECTIVE 2

List the items to be checked during pre-alignment inspection. Write these items in the following blanks.

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

OBJECTIVE 3

Select from a list true statements about the types, sizes, and construction of tires. Write an "X" in the blanks before true statements.

______1. Tubeless pneumatic tires are normally used today.

______2. Self-sealing tires use an inner coating of sealant that stops air leakage when the tire is punctured.

______3. Simple tubeless tires are normally used today.

______4. To make retreads, new tread is applied with metal studs.

______5. Self-sealing tires are filled with a sealant instead of air.

______6. Retreads are made by applying new tread by heat and pressure.

______7. Tire sizes used to be alpha-numeric, but now they are metric.

______8. Tire sizes are actually a series of measurements or details about the tire.

______9. Tire sizes can be alpha-numeric or metric.

______10. Tire sizes are codes set by each manufacturer.

______11. Bias plies have layers running from bead to bead and stabilizer belts under the tread.

______12. Radials have layers running from bead to bead and stabilizer belts under the tread.

_____13. Bias tires use an older design.

_____14. Stabilizer belts are never used with plies.

OBJECTIVE 4

List and describe the types of wheel-balancing machines. In the following blanks list the types and write the description of each.

1. ____________________

2. ____________________

3. ____________________

WRITTEN TEST ANSWERS

PERFORM PRE-ALIGNMENT INSPECTIONS V

OBJECTIVE 1

1. B
2. D
3. C
4. C
5. D
6. A
7. C
8. B
9. A
10. A

OBJECTIVE 2

1. Tire and wheel assemblies
2. Wheel bearings
3. Vehicle height
4. Suspension system components and operation
5. Steering system components and operation

OBJECTIVE 3

The following should have an "X" in the blank:

1, 2, 6, 8, 9, 12, 13

OBJECTIVE 4

The answer should include all of the following:

- **Bubble-type** — Balances the tire and wheel assembly removed from the vehicle by using a bubble to indicate whether part of the assembly is heavier than other parts; checks static balance only
- **Off-car** — Balances the tire and wheel assembly removed from the vehicle by spinning the assembly and indicating vibration due to imbalance by either an electronic or hand-operated device; some types check only dynamic balance, others check both static and dynamic balance
- **On-car** — Balances the tire and wheel assembly together with the hub and brake drum or rotor by spinning the assembly while mounted and indicating the vibration due to imbalance by either a mechanical or electronic device; some types check only dynamic balance, others check both static and dynamic balance

OBJECTIVE SHEET

ADJUST WHEEL ALIGNMENT

VI

INTRODUCTION

In order for a vehicle to steer efficiently and have proper directional control, the wheels must be in correct alignment. Wheel alignment affects tires too. Proper alignment adjustments help increase the life of a vehicle's tires by preventing abnormal tire wear. The skills necessary to perform wheel alignment service are very important to the steering and suspension technician. To align a vehicle's wheels, the technician must thoroughly understand the operations of the steering and suspension systems, the causes of abnormal tire wear, and the effects of incorrect alignment angles. It is just as important for the technician to understand how to check and adjust alignment angles to correct problems caused by improper alignment settings.

PREREQUISITES

Before studying this unit, the student should have successfully completed Unit 5, *Perform Pre-Alignment Inspections.*

UNIT OBJECTIVE

After completing this unit, the student should be able to measure and adjust wheel alignment angles. The student will demonstrate these competencies by completing the assignment sheet, job sheets, and written test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completing this unit, the student should be able to show the ability to:

1. Select definitions of terms associated with wheel alignment.
2. State the purposes of wheel alignment.
3. List alignment angles.
4. List in order the steps for measuring and adjusting wheel alignment angles.
5. Match types of wheel alignment devices to their functions.
6. Identify the parts of a wheel alignment machine.
7. Interpret alignment specifications to analyze alignment angle readings. (Assignment Sheet 1)

8. Demonstrate the ability to:

   A. Set up a wheel alignment machine for a two-wheel and a four-wheel alignment procedure. (Job Sheet 1)

   B. Measure and adjust front-to-rear tracking. (Job Sheet 2)

   C. Measure and adjust camber. (Job Sheet 3)

   D. Measure and adjust caster and measure toe-out on turns. (Job Sheet 4)

   E. Measure steering axis inclination. (Job Sheet 5)

   F. Measure and adjust toe. (Job Sheet 6)

PREPARATION

- Review the unit and plan the presentation. Study the specific objectives to determine the order in which you will present the objectives.

- Review the teaching suggestions given in the Delivery and Application sections and plan classroom activities. Also note the suggestions for media and supplemental materials.

- Plan the presentation to take advantage of student learning styles and accommodate students with special needs.

- Many multiple-choice test questions (in the Pretests, Assignment Sheets, and Written Test) for this curriculum have been written in a style that is similar to the questions on the ASE certification test. Like ASE questions, the student should select the item that **BEST** answers the question. *The student should make no additional assumptions about a question other than those specifically given in the question.* A special effort has been made to provide good distracters for each question which will make the student think through the answer. It is suggested that the instructor review the answers to every test before reviewing the test with the students so that he or she is not caught off guard by such distracters.

- Obtain films, videotapes, and other media to supplement the instruction of this unit. See ordering information in the Suggested Resources section. Include in your selection media that demonstrate job sheet skills. Videotape your own demonstrations of job sheet procedures if you are unable to obtain suitable media.

- Obtain competency profiles.

  NOTE: Competency profiles for this book are available from the Curriculum and Instructional Materials Center, Oklahoma Department of Vocational and Technical Education, 1500 West Seventh Avenue, Stillwater, Oklahoma 74074-4364.

- Prepare the classroom and shop. Display posters, charts, safety signs, etc., that emphasize wheel alignment service. Have articles, specification guides, and other references about wheel alignment available for student use.

- Discuss with the students the purpose of pretesting. Explain that they will be asked to complete a written pretest and that they will be required to demonstrate assignment sheet competencies and job sheet skills as part of the pretesting process.

- Provide the students with the equipment and materials necessary to complete the pretest. Administer the pretest.

- Assess student competencies. Consider the results of student competencies as you prepare your presentation for each objective.

DELIVERY

Unit introduction

- Discuss the introduction to the unit. (See the Objective Sheet.)

- Discuss the unit objective and then the specific objectives. Emphasize how accomplishing the specific objectives will lead to meeting the unit objective and how reaching the unit objective is vital to becoming an automotive steering and suspension technician. Also relate the objective to your introduction and to material previously covered.

Objective 1 Select definitions of terms associated with wheel alignment.

- Show the students examples of as many of the terms listed in this objective as possible.

- Explain the terms *static alignment machine* and *dynamic alignment machine*, and discuss the differences between these two types of machines.

- Discuss the terms *vehicle center line, geometric center line*, and *thrust line*. Use Transparencies 2 and 3 to explain these terms.

- Explain the terms associated with front-to-rear tracking: *axle offset, wheel setback*, and *axle side-set*. Discuss the illustrations presented with these terms.

Objective 2 State the purposes of wheel alignment.

- Discuss each of the purposes listed and explain to the students how proper wheel alignment helps ensure each purpose is met.

- Discuss the boxed material, "Wheel Alignment."

- Show the films *Alignment and Adjustments* and *Front Suspension Overhaul and Alignment.*

Objective 3 List alignment angles.

- Review with the students the five alignment angles presented. Have the students refer to the information sheet in Unit 2, *Service Steering Systems* and review the illustrations of each of these angles in Transparencies 1-9.

- Explain to the students that the steering axis inclination (SAI) and the turning radius are not adjustable angles.

- Discuss which angles that are adjustable on some vehicles and cannot be adjusted on other vehicles.

Objective 4 List in order the steps for measuring and adjusting wheel alignment angles.

- Discuss the boxed material, "Order of Adjustment." Emphasize to the students the order of adjustment: camber, caster, toe.

- Review the ordered steps for measuring and adjusting presented. Explain to the students that although camber, caster, and toe are usually adjusted in that order, all angles are usually measured before any angles are adjusted. For example, both rear camber and rear toe are measured before either are adjusted; then front-wheel angles are measured and adjusted.

- Emphasize to the students that they must know not only the steps presented in this objective but they also must know the *order* of the steps.

Objective 5 Match types of wheel alignment devices to their functions.

- Discuss the functions of each alignment device listed and point out those that are most commonly used today.
- Tour the shop, point out the various wheel alignment devices discussed, and explain the advantages and disadvantages of using each.

Objective 6 Identify the parts of a wheel alignment machine.

- Tour the shop and point out on the actual alignment equipment the various parts shown in this objective.
- Explain how some of the devices presented in Objective 6 work to measure alignment angles.

APPLICATION

Objective 7 Interpret alignment specifications to analyze alignment angle readings. (Assignment Sheet 1)

- Review adding and subtracting positive and negative numbers with the students. Refer the students to Unit A-4, Apply Math and Related Measuring, of *Introduction to Automotive Service* if necessary.
- Explain the meaning of the plus-or-minus sign, and tell students how this sign is used in alignment specification information. Give students specific examples, such as 2° ± ½° means a range between 1½° to 2½°.
- Discuss *nominal*, *maximum*, and *minimum* settings. Use Transparency 1, Alignment Specifications Table, to aid in your discussion.
- Explain *service checking range* and *checking range* and discuss when alignment angles should be corrected even if their measurements fall within the specified range. Include in your discussion how other factors, such as tire wear, should be considered when deciding whether adjustment is necessary.
- Show the students Transparency 1 and give them examples of caster and/or camber settings that are not within the maximum variation allowed between wheels.

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- Explain how some service manuals provide charts to show caster or camber settings to be used when compensating for different vehicle heights.

- Discuss degrees and fractional and decimal portions of degrees. Explain that specifications for caster and camber can be expressed in fractional degrees, decimal degrees, or minutes and those for toe can be expressed in either degrees, inches, or millimeters.

- Have the students complete Assignment Sheet 1. When all students have completed the assignment, discuss it in class.

Objective 8A Set up a wheel alignment machine for a two-wheel and a four-wheel alignment procedure. (Job Sheet 1)

- Have the students review the definitions of *static alignment machine* and *dynamic alignment machine* and explain the differences between the two.

- Show the students the alignment machine(s) in your shop and explain the features. Discuss the different devices found on other types of alignment equipment.

- Discuss the importance of correctly positioning the vehicle on the alignment rack.

- Stress to students the importance of handling alignment heads correctly. Explain that equipment manufacturers provide for servicing alignment equipment.

- Show media presentations, *Alignment and Adjustments* and *Front Suspension Overhaul and Alignment.*

- Discuss the equipment and materials used in Job Sheet 1. Review applicable safety rules and precautions and the guidelines given in the job sheet introduction.

- Demonstrate Job Sheet 1. Have the students practice Job Sheet 1 until they are ready to take the practical test.

- Invite various alignment equipment manufacturers to demonstrate new alignment techniques.

Objective 8B Measure and adjust front-to-rear tracking. (Job Sheet 2)

- Review the terms *geometric center line* and *thrust line*. Explain to the students that wheels are aligned with the thrust line if the rear wheels are not adjustable.
- Demonstrate the effects of *axle offset*, *wheel setback*, and *axle side-set* using a mockup. Construct or obtain a small vehicle that has a rear axle that can be shifted and bent. Adjusting the rear axle accordingly, show the students how axle offset and axle side-set causes the model vehicle to *dog track*.
- Discuss the different methods of measuring tracking and explain why some methods are more accurate than others.
- Discuss the equipment and materials used in Job Sheet 2. Review applicable safety rules and precautions and the guidelines given in the job sheet introduction.
- Demonstrate Job Sheet 2. Have the students practice Job Sheet 2 until they are ready to take the practical test.

Objective 8C Measure and adjust camber. (Job Sheet 3)

- Have the students review Student Supplement 1, Methods of Adjusting Wheel Alignment, and show them Transparency 10, Camber. Discuss those adjustments that are used to correct camber.
- Explain to the students that although this job sheet addresses measuring and adjusting only camber, usually caster and camber are both measured before either is adjusted. This is because both adjustments are often made at the same adjustment points. Practical tests can be combined.
- Have the students refer to service manuals and other reference manuals and find camber specifications for various makes and models of vehicles.
- Illustrate camber adjustment at the upper control arm by using a triangle and straight line. Cut a triangle, having sides measuring at least 10 inches, from poster board, cardboard, or plywood. On a flat surface large enough on which to place the triangle, draw a straight line. Lay the triangle on a flat surface, having one side of triangle along the line. By moving the triangle away from the line, show the students how adding shims or sliding the control arm in or out changes the position of the upper ball joint.

- Show the students manufacturers' bulletins that discuss new adjustment kits and explain kit installations. Also show the students where they can find information about various aftermarket kits. Discuss how caster can be corrected using such kits.

- Show the students a mechanical caster/camber gauge with a bubble level. Demonstrate how it is used to measure camber angles and relate these concepts to how camber is measured with wheel alignment equipment.

- Discuss the equipment and materials used in Job Sheet 3. Review applicable safety rules and precautions and the guidelines given in the job sheet introduction.

- Demonstrate Job Sheet 3. Have the students practice Job Sheet 3 until they are ready to take the practical test.

Objective 8D Measure and adjust caster and measure toe-out on turns. (Job Sheet 4)

- Have the students review Student Supplement 1, Methods of Adjusting Wheel Alignment, and discuss those adjustments that are used to correct caster.

- Have the students refer to service manuals and other reference manuals and find caster specifications for various makes and models of vehicles.

- Using the same wooden triangle and surface with a straight line discussed in Job Sheet 3 teaching suggestions, show how adjustments made at the control arm affect caster setting.

- Show the students a mechanical caster/camber gauge with a bubble level. Demonstrate how it is used to measure camber angles and relate these concepts to how camber is measured with wheel alignment equipment.

- Discuss the equipment and materials used in Job Sheet 4. Review applicable safety rules and precautions and the guidelines given in the job sheet introduction.

- Demonstrate Job Sheet 4. Have the students practice Job Sheet 4 until they are ready to take the practical test.

Objective 8E Measure steering axis inclination. (Job Sheet 5)

- Review the definition of *included angle* from Unit 2, *Service Steering Systems*. Explain that the SAI angle and camber angle together form the included angle and that the SAI angle measurement should always be constant.

- Explain to students that the SAI angle and KPI angle are the same and that KPI angle refers to the angle in those suspension systems having king pins connecting the steering knuckle assembly to the spindle.

- Explain to the students some of the various ways that different alignment equipment obtains SAI readings.

- Explain to students how SAI reduces the need for excessive camber.

- Discuss the equipment and materials used in Job Sheet 5. Review applicable safety rules and precautions and the guidelines given in the job sheet introduction.

- Demonstrate Job Sheet 5. Have the students practice Job Sheet 5 until they are ready to take the practical test.

Objective 8F Measure and adjust toe. (Job Sheet 6)

- Have the students review Job Sheet 5 in Unit 2, *Service Steering Systems*, and discuss the parts of the tie-rod assemblies on both rack-and-pinion and parallelogram steering systems.

- Discuss the different devices used to measure toe. Demonstrate the procedures for measuring toe using the devices available in your shop.

- Explain to the students that on some vehicles with rack-and-pinion steering the rack cannot be in the exact center of the vehicle, and therefore when toe is adjusted, the number of exposed threads on the left and right tie-rod assemblies cannot be the same.

- Discuss the equipment and materials used in Job Sheet 6. Review applicable safety rules and precautions and the guidelines given in the job sheet introduction with the students.

- Demonstrate Job Sheet 6. Have the students practice Job Sheet 6 until they are ready to take the practical test.

Unit summary activity

- Discuss Activity Sheet 1, Answer General Questions About Wheel Alignment Adjustments. The purpose of the activity is to provide students with the opportunity to practice answering questions similar in content and style to those found on the actual ASE certification test. Keep this in mind when discussing the assignment.
- Have the students complete Activity Sheet 1.

EVALUATION

- Give the written test.
- Give the practical tests and evaluate the tests on the forms provided.
- Reteach and retest as required.
- Complete the appropriate section of the competency profiles.

SUGGESTED RESOURCES

Resources used in developing unit

- Bacon, Miles E. *Automotive Steering, Suspension, and Wheel Alignment Shop Manual.* New York: Gregg Division, McGraw-Hill Book Co., 1988.
- Coghlan, David A. *Automotive Chassis Systems: Steering, Suspension, Alignment, and Brakes*, 2nd ed. Boston: Breton Publishers, A Division of Wadsworth, Inc., 1985.
- Crouse, William H., and Donald L. Anglin. *Automotive Brakes, Suspension, and Steering.* New York: Gregg Division, McGraw-Hill Book Co., 1983.
- Crouse, William H., and Donald L. Anglin. *Automotive Mechanics*, 9th ed. New York: Gregg Division, McGraw-Hill Book Co., 1985.
- Duffy, James E. *Modern Automotive Mechanics.* South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1985.
- Ellinger, Herbert E., and Richard B. Hathaway. *Automotive Suspension and Steering: Theory and Service.* Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1989.

- *Ford 1987 Car Shop Manual, Body/Chassis/Electrical: Lincoln Town Car, Ford Crown Victoria, Mercury Grand Marquis.* Dearborn, Michigan: Ford Parts and Service Division, Training and Publications Department, 1986.

- *Ford 1988 Truck Shop Manual: Aerostar.* Dearborn, Michigan: Ford Parts and Service Division, Training and Publications Department, 1987.

- *Four-Wheel Alignment Seminar.* Bridgeton, Missouri: Hunter Engineering Co., 1981.

- *Moog Front-End Service Manual.* St. Louis, Missouri: Moog Automotive Inc., 1982.

- *1986 Chrysler Engine-Chassis-Body Service Manual: 1986 Front Wheel Drive Passenger Vehicles—Lancer, Daytona, New Yorker, Dodge 600, Aries, Omni, LeBaron GTS, Laser, LeBaron, Caravelle, Reliant, Horizon.* Centerline, Michigan: Chrysler Corp., 1985.

- *1986 Shop Manual: Caprice, Monte Carlo, El Camino.* Detroit, Michigan: General Motors Corp., Chevrolet Motor Division, 1985.

- *1988 Celebrity Service Manual.* Detroit, Michigan: General Motors Corp., Chevrolet Motor Division, 1987.

- *1989 Geo Metro Service Manual.* Detroit, Michigan: General Motors Corp., 1988.

- *1990 Chevrolet Light Duty Truck Service Manual: C-K Truck Models.* Warren, Michigan: General Motors Corp., Chevrolet Motor Division, 1989.

- *Steering, Suspension, Wheel Alignment and Balance: Student Reference Book.* Centerline, Michigan: Chrysler Corp., Service and Parts Operations, Training Program Development Department, n.d.

- *Steering, Suspension, and Wheel Service, Unit 4: Wheel Alignment*, rev. ed. Tallahassee, Florida: The Center For Studies in Vocational Education, Florida State University, 1981.

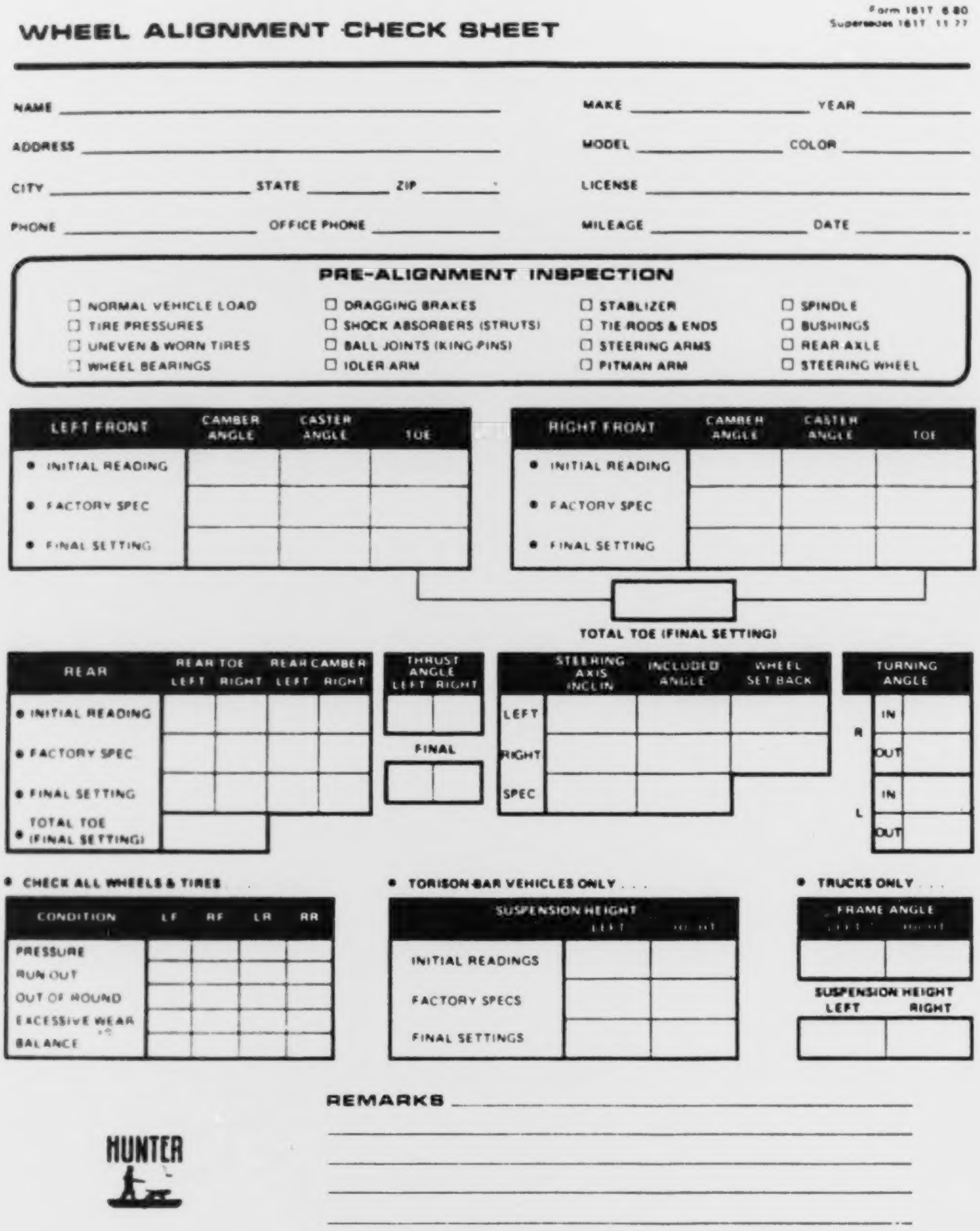
- Stockel, Martin W., and Martin T. Stockel. *Auto Service and Repair.* South Holland, Illinois: The Goodheart-Willcox Co., Inc., 1984.

Media

- *Alignment and Adjustments.* 13 minutes, color VHS videotape. Bergwall Productions, Inc., P.O. Box 238, Garden City, NY 11530-0238, phone 1-800-645-3565. This videotape covers prealignment inspections and wheel alignment using Bear equipment.

- *Front Suspension Overhaul and Alignment.* 16 minutes, color VHS videotape. Bergwall Productions, Inc., P.O. Box 238, Garden City, NY 11530-0238, phone 1-800-645-3565. This videotape covers prealignment inspections, wheel alignment using Hunter equipment, and MacPherson strut replacement.

  NOTE: This videotape is one of three in the series titled *Front Wheel Drive Explained.*



WHEEL ALIGNMENT CHECK SHEET

Form 1617 6 80
Supersedes 1617 11 77

NAME ____________________
MAKE ____________ YEAR ____________
ADDRESS ____________________
MODEL ____________ COLOR ____________
CITY ____________ STATE ________ ZIP ________
LICENSE ____________________
PHONE ____________ OFFICE PHONE ____________
MILEAGE ____________ DATE ____________

PRE-ALIGNMENT INSPECTION

- ☐ NORMAL VEHICLE LOAD
- ☐ TIRE PRESSURES
- ☐ UNEVEN & WORN TIRES
- ☐ WHEEL BEARINGS
- ☐ DRAGGING BRAKES
- ☐ SHOCK ABSORBERS (STRUTS)
- ☐ BALL JOINTS (KING PINS)
- ☐ IDLER ARM
- ☐ STABLIZER
- ☐ TIE RODS & ENDS
- ☐ STEERING ARMS
- ☐ PITMAN ARM
- ☐ SPINDLE
- ☐ BUSHINGS
- ☐ REAR AXLE
- ☐ STEERING WHEEL

LEFT FRONT	CAMBER ANGLE	CASTER ANGLE	TOE
● INITIAL READING			
● FACTORY SPEC			
● FINAL SETTING			

RIGHT FRONT	CAMBER ANGLE	CASTER ANGLE	TOE
● INITIAL READING			
● FACTORY SPEC			
● FINAL SETTING			

TOTAL TOE (FINAL SETTING) ________

REAR	REAR TOE		REAR CAMBER	
	LEFT	RIGHT	LEFT	RIGHT
● INITIAL READING				
● FACTORY SPEC				
● FINAL SETTING				
● TOTAL TOE (FINAL SETTING)				

THRUST ANGLE	
LEFT	RIGHT
FINAL	

	STEERING AXIS INCLIN	INCLUDED ANGLE	WHEEL SET BACK
LEFT			
RIGHT			
SPEC			

TURNING ANGLE		
R	IN	
	OUT	
L	IN	
	OUT	

● CHECK ALL WHEELS & TIRES . . .

CONDITION	LF	RF	LR	RR
PRESSURE				
RUN OUT				
OUT OF ROUND				
EXCESSIVE WEAR				
BALANCE				

● TORISON-BAR VEHICLES ONLY . . .

SUSPENSION HEIGHT	LEFT	RIGHT
INITIAL READINGS		
FACTORY SPECS		
FINAL SETTINGS		

● TRUCKS ONLY . . .

FRAME ANGLE	
LEFT	RIGHT

SUSPENSION HEIGHT	
LEFT	RIGHT

REMARKS ____________________

HUNTER

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PRETEST ANSWERS

ADJUST WHEEL ALIGNMENT

VI

EVALUATOR NOTE

Use the following answer key to check student answers to pretest questions. To determine the students' individual study requirements from the pretest results, use the following table which shows the correlation between the objectives and pretest questions. Then counsel the students individually on pretest results and study requirements.

TABLE

Correlation between objectives and pretest questions:

Objective	Question
1	1, 14, 26, 27
2	2, 34
3	3
4	4, 15
5	5, 16
6	6, 7
7	17, 18, 19
8A	8, 20, 28
8B	9, 21, 29
8C	10, 22, 30
8D	11, 23, 31
8E	12, 24, 32
8F	13, 25, 33

ANSWER KEY

1. C
2. A
3. C
4. B
5. D
6. B
7. D
8. B
9. C
10. D
11. B
12. B
13. D
14. A
15. C
16. C
17. C
18. D
19. C
20. C
21. D
22. B
23. A
24. C
25. C
26. D
27. A
28. C
29. C
30. B
31. D
32. A
33. C
34. A

PRETEST

ADJUST WHEEL ALIGNMENT

VI

NAME ______________________________ SCORE ________

DIRECTIONS

Read the following questions and problems. Select the item that best answers the question or solves the problem and write the correct letter in the blank.

______1. Which of the following statements best defines *static alignment machine*?

A. Machine that measures the alignment angles of the wheels while the wheels are stationary; takes alignment readings from tire contact with the road surface
B. Machine that measures the alignment angles of the wheels while the wheels are rotating; takes alignment readings from tire contact with the road surface
C. Machine that measures the alignment angles of the wheels while the wheels are stationary; takes alignment readings from the spindle
D. Machine that measures the alignment angles of the wheels while the wheels are rotating; takes alignment readings from the spindle

______2. Which of the following is **not** a purpose of wheel alignment?

A. To correct suspension system problems
B. To ensure efficient steering and proper directional control
C. To prevent abnormal tire wear
D. To ensure proper tracking of the wheels

______3. Technician A says one vehicle alignment angle is turning radius. Technician B says steering axis inclination is a vehicle alignment angle. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

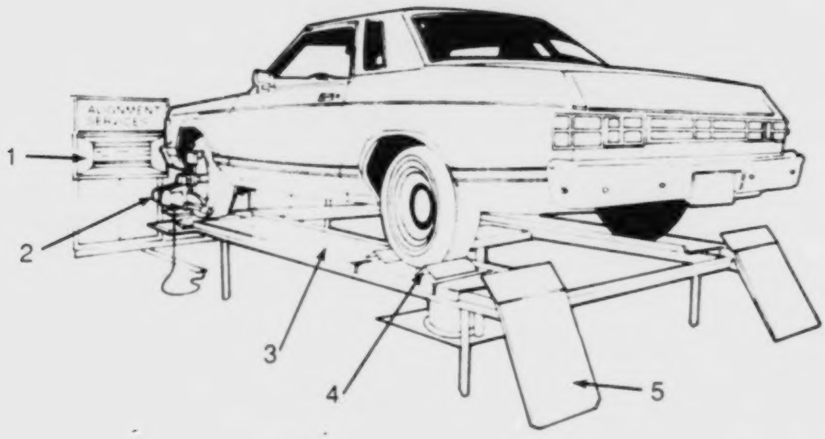
______4. Which of the following statements is correct?

- A. Front toe should be measured and adjusted before adjusting the rear toe
- B. Rear camber should be measured and adjusted before measuring and adjusting front caster and camber
- C. Front camber and caster should be measured and adjusted before measuring and adjusting rear camber
- D. None of the above

______5. Which of the following is the function of a *scuff gauge*?

- A. Measures toe setting by using a light beam, mirror, and scale
- B. Measures toe-out on turns by using turning devices with gauges under the front wheels; also used in conjunction with other devices to measure caster
- C. Measures caster, camber, and steering axis inclination by using bubble-level indicators
- D. Measures sideways drag of tires, indicating whether a vehicle has excessive toe-in or toe-out

For items 6 and 7, refer to the illustration below:



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______6. The part labeled 4 is a/an:

A. Turning radius gauge
B. Wheel chock
C. Ramp
D. None of the above

______7. The part labeled 1 is the:

A. Caster angle adjustment device
B. Toe gauge
C. Alignment head
D. Alignment readings display

______8. Which of the following statements about wheel alignment equipment is correct?

A. Vehicles must be secured to the alignment rack with chains, regardless of what type of alignment machine is used
B. Wheel alignment equipment should be checked periodically to be sure that readings are accurate
C. Wheel alignment heads are permanently connected to the wheel alignment machine
D. All of the above

______9. Technicians A and B are discussing front-to-rear tracking. Technician A says on some vehicles the wheels are aligned with the geometric center line. Technician B says wheels are sometimes aligned with the thrust line. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____10. Which of the following statements about camber adjustment is correct?

A. Camber should be adjusted after caster is adjusted
B. Toe-in should be adjusted before camber is adjusted
C. Caster should be adjusted before camber is adjusted
D. Camber and caster can be adjusted at the same time

_____11. Technicians A and B are discussing caster adjustments made by adding or subtracting shims at the upper control arm. Technician A says these types of adjustments change the camber angle and camber must be rechecked after caster adjustment. Technician B says camber is not affected if the number shims removed from the front or back of the control arm is equal to the number added to the front or back. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____12. What is the purpose of the SAI angle?

A. To decrease the need for excessive caster
B. To decrease the need for excessive camber
C. To decrease the need for excessive toe-in
D. To decrease the need for excessive toe-out

_____13. Which of the following statements is **not** correct?

A. Mechanical toe gauges can be used to measure toe
B. Tie-rod assemblies are adjusted to change toe setting
C. Toe is adjusted after camber and caster are adjusted
D. The toe adjustment procedure for vehicles with rack-and-pinion steering is not similar to the adjustment procedure for vehicles with parallelogram steering

_____14. Which of the following best defines *geometric center line*?

- A. Line passing through the midpoint of the front and rear axles of the vehicle
- B. Line passing through the center of the vehicle crosswise
- C. Line of drive direction passing through the midpoint of the rear axle of the vehicle
- D. Line passing through the center of the vehicle lengthwise

_____15. Technician A says the rear camber and toe should be measured and adjusted before the front caster is adjusted. Technician B says the rear camber and toe should be measured and adjusted before the front camber is adjusted. Who is correct?

- A. Technician A
- B. Technician B
- C. Both A and B
- D. Neither A nor B

_____16. A device that measures toe setting using a sensor mounted to an adaptor that is attached to the wheel rim is:

- A. A mechanical gauge
- B. A turning radius gauge
- C. An electronic toe gauge
- D. A mechanical toe gauge

For items 17-19, refer to the alignment specifications table below:

WHEEL ALIGNMENT SPECIFICATIONS			
VEHICLE	**OPERATION**	**SERVICE CHECKING**	**SERVICE SETTING**
CELEBRITY	CASTER (FRONT)	+ 1.7° = 1°	NOT ADJUSTABLE
	CAMBER (FRONT)	0° ± .5°	0° (A)
	CAMBER (REAR)	0° ± 2.5°	NOT ADJUSTABLE
	TOE (FRONT)	0° ± 1°	0° (B)
	TOE (REAR)	0° = 2°	NOT ADJUSTABLE

NOTICE Vehicle must be jounced 3 times before checking alignment to eliminate false geometry readings.

(B) TOE Left and right side to be set separately per wheel and steering wheel must be held in straight ahead position with ± 5.0° (1.2 mm).

(A) Left and right side to be equal within .50°.

CASTER The limits on caster are + .7° to + 2.7°.

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_____17. Which of the following caster readings is **not** within specifications?

A. 0.7°
B. 2.1°
C. −1.7°
D. 1.8°

_____18. Which of the following front wheel camber readings is **not** within specifications?

A. −0.05°
B. 0.05°
C. 0.50°
D. −5.0°

_____19. Technicians A and B are discussing the alignment readings of the vehicle whose specifications appear in this table. The camber reading for the left front wheel is -0.2° and the reading for the right front wheel is 0.5°. Technician A says each reading is within specifications. Technician B says there is too much difference between the readings of the wheels, and camber should be adjusted. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____20. Technicians A and B are discussing the set-up of wheel alignment machines. Technician A says the vehicle should be centered on the alignment rack. Technician B says the wheels should be centered on the turntables. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____21. Incorrect tracking can be caused by which of the following?

A. Damaged frame
B. Bent or damaged axle
C. Damaged suspension components
D. All of the above

_____22. All of the following are used to adjust camber settings **except**:

A. Slotted holes
B. Shims at strut rod connections
C. Shims at upper control arm connections
D. Cam bolts

_____23. Technician A says toe-out on turns is not adjustable and angle readings that are not within specifications can indicate that the steering knuckle assembly is bent. Technician B says toe-out on turns is not adjustable on any vehicle, but adjustment kits can be used to change toe-out on turns. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____24. Which of the following statements is correct?

A. The steering axis inclination angle is equal to the included angle plus the camber angle
B. The camber angle is equal to the steering axis inclination angle minus the included angle
C. The steering axis inclination angle is equal to the included angle minus the camber angle
D. None of the above

_____25. Technician A says toe-in specifications are given in inches. Technician B says toe-in specifications are given in degrees. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____26. Which of the following best defines *thrust line*?

A. Line passing through the midpoint of the front and rear axles of vehicle
B. Line of drive direction passing through the midpoint of the front axle of the vehicle
C. Line passing through the center of the vehicle lengthwise
D. Line of drive direction passing through the midpoint of the rear axle of the vehicle

_____27. *Condition in which the geometric center line is not parallel to or the same as the thrust line: the rear axle is not perpendicular to the center line* is the definition of:

A. Axle offset
B. Axle side-set
C. Wheel setback
D. Thrust side-set

_____28. Technicians A and B are discussing wheel alignment equipment. Technician A says alignment heads should be periodically checked and recalibrated. Technician B says alignment heads need to be recalibrated if they are dropped or damaged in some way. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____29. Which of the following statements about tracking adjustment is correct?

A. Thrust line alignment is the process of aligning the wheels with the geometric center line
B. Vehicle center line alignment is the process of aligning the wheels with the thrust line of the vehicle rather than the geometric center line
C. Geometric center line alignment is the process of aligning the wheels with the vehicle center line; the vehicle center line, the thrust line, and the geometric center line should all be the same line
D. None of the above

_____30. Technician A says the camber setting is always the same for both front wheels. Technician B says the camber setting is sometimes different for left and right front wheels in order to compensate for the additional weight of the driver. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____31. Which of the following statements about caster adjustment is correct?

A. Shims can be used to adjust caster
B. Strut rods can be adjusted to change caster settings
C. Caster can be adjusted by installing aftermarket adjustment kits
D. All of the above

_____32. Technicians A and B are discussing measuring steering axis inclination. Technician A says if the steering axis inclination reading is not within specifications, the spindle might be bent. Technician B says if the reading is not within specifications, the camber adjustment can be incorrect. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____33. Which of the following statements about toe adjustment is correct?

A. If the steering knuckle is attached to the front of the spindle assembly, increase toe-in by lengthening the tie-rod assemblies
B. If the steering knuckle is attached to the front of the spindle assembly, decrease toe-in by shortening the tie-rod assemblies
C. If the steering knuckle is attached to the rear of the spindle assembly, increase toe-in by lengthening the tie-rod assemblies
D. Both A and B

_____34. Technician A says one purpose of wheel alignment is to prevent abnormal tire wear. Technician B says the purpose of wheel alignment is to check suspension components for damage. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

OBJECTIVE 1

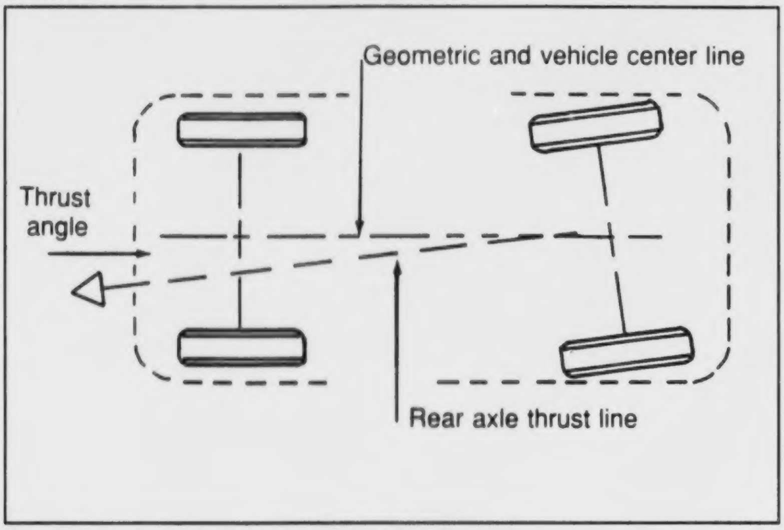
Select definitions of terms associated with wheel alignment.

axle side-set — Condition in which the vehicle center line and the geometric center line are not the same line (Figure 1)

NOTE: This condition is sometimes called *dog tracking* because the rear wheels do not directly follow the front wheels.

EXAMPLE:

FIGURE 1



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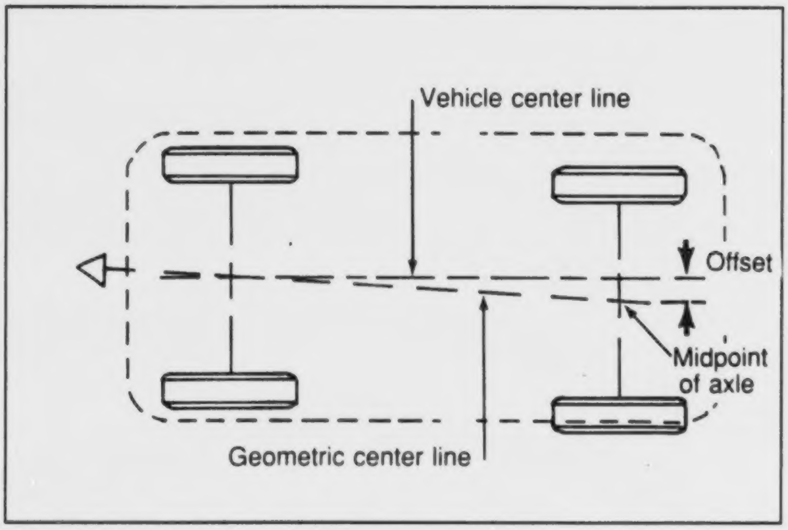
axle offset — Condition in which the geometric center line is not parallel to or the same as the thrust line; the rear axle is not perpendicular to the center line (See Figure 2.)

NOTE: This condition may also be called *dog tracking.*

EXAMPLE:

FIGURE 2



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computerized alignment machine — Machine that measures alignment angles and uses a computer graphic display to indicate readings

NOTE: One feature computerized alignment machines have that other types of alignment machines do not have is that changes in alignment readings can be observed as alignment adjustments are made.

dynamic alignment machine — Machine that measures the alignment angles of the wheels while the wheels are rotating; takes alignment readings from tire contact with the road surface

NOTE: Most dynamic alignment machines are capable of aligning both the front and the rear wheels; however, some only align front wheels. Almost all dynamic aligners are computerized.

geometric center line — Line passing through the midpoint of the front and rear axles of the vehicle (See Figure 1.)

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static alignment machine — Machine that measures the alignment angles of the wheels while the wheels are stationary; takes alignment readings from the spindle

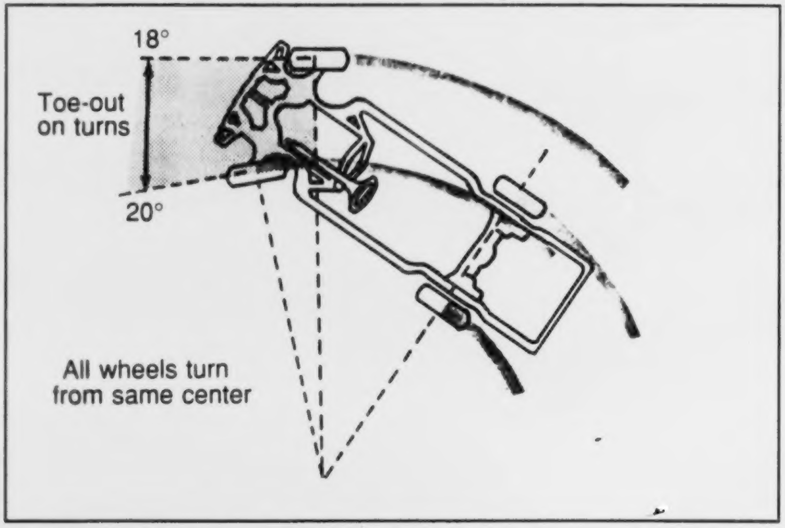
NOTE: Some, but not all, static alignment machines are computerized.

thrust line — Line of drive direction passing through the midpoint of the rear axle of the vehicle (See Figure 2.)

toe-out on turns — A characteristic of steering systems during turns in which the inner wheel turns more sharply than the outer wheel (Figure 3)

EXAMPLE:

FIGURE 3



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turning radius — The diameter of the circle made by the outer tire during a full turn

vehicle center line — Line passing through the center of the vehicle lengthwise (See Figure 1.)

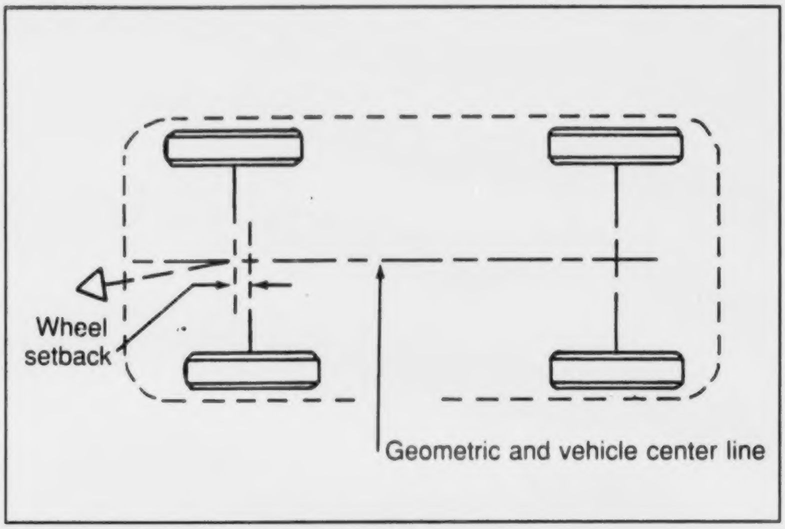
NOTE: The vehicle center line passes through the center of the vehicle but does not necessarily intersect the axles at their midpoints.

wheel setback — Condition in which one wheel spindle is not aligned with the opposite wheel spindle, but a line through the spindle of each wheel is perpendicular to the center line of the vehicle (Figure 4)

NOTE: With wheel setback, one spindle is more rearward or forward than the other spindle. Wheel setback is always an abnormal condition. It can be caused by an accident or other unusual circumstance.

EXAMPLE:

FIGURE 4



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OBJECTIVE 2 **State the purposes of wheel alignment.**

- To insure efficient steering and proper directional control
- To prevent abnormal tire wear
- To insure proper tracking of the wheels

WHEEL ALIGNMENT

Have you ever thought about just how a vehicle operates or why it handles the way it does? Much planning goes into each design in order for the vehicle to operate properly, safely, and efficiently. One of the primary factors that are considered when a vehicle is designed are the different alignment angles. Each of these angles has a purpose. For instance, camber, caster, and toe are *directional control angles.* They help control the direction of the vehicle and aid the driver in steering. Camber and toe are *tire-wearing angles*, and they help maximize the useful life of a vehicle's tires. In order for these angles to serve their intended purpose, they must be correctly set to the vehicle manufacturer's specifications. The gradual wearing of tires and suspension parts causes the alignment angles to change; therefore, these angles must be checked and adjusted on a regular basis.

OBJECTIVE 3 **List alignment angles.**

- Caster
- Camber
- Steering axis or kingpin inclination (SAI or KPI)
- Turning radius
- Toe
- Toe-out on turns

OBJECTIVE 4

List in order the steps for measuring and adjusting wheel alignment angles.

1. Measure rear camber and toe; record measurements
2. Measure front camber, caster, and toe; record measurements

   NOTE: If these measurements are more than ± 2° from manufacturer specifications, check for damage before attempting to adjust alignment angles.

3. Compare the measurements to manufacturer specifications to determine required adjustments.

   NOTE: Students should confirm the needed adjustments with their instructor.

4. Adjust rear camber to specifications
5. Adjust rear toe to specifications
6. Adjust front camber and caster to specifications
7. Adjust front toe to specifications
8. Remeasure all alignment angles

ORDER OF ADJUSTMENT

The three alignment angles that can be adjustable are camber, caster, and toe. Although camber and caster angles on some vehicles can be factory set and are not adjustable, toe is adjustable on any vehicle. Whether or not an angle can be adjusted, it must always be measured, and its reading compared with the vehicle manufacturer's specifications. Toe is always set after caster and camber. As indicated in the list above, all measurements should be taken and recorded before any adjustments are performed. Front-end toe must be close to manufacturer specifications before the rear alignment angles are adjusted. Correcting rear camber and toe corrects the front-to-rear tracking, and tracking should always be adjusted before the front wheels are adjusted. When aligning the front wheels, it is very important to remember the order in which camber, caster, and toe are adjusted. One easy way to do this is to remember that their order of adjustment is alphabetical as listed below.

1. Camber
2. Caster
3. Toe

OBJECTIVE 5

Match types of wheel alignment devices to their functions.

dynamic wheel aligner — Measures toe, caster, and camber electronically by turning the wheels with sets of rollers

NOTE: A dynamic wheel aligner measures alignment angles under conditions similar to regular driving conditions.

electronic toe gauge — Measures toe setting using a sensor mounted to an adaptor attached to the wheel rim

light beam alignment tester — Measures camber and caster by using light beams from projectors attached to the wheels

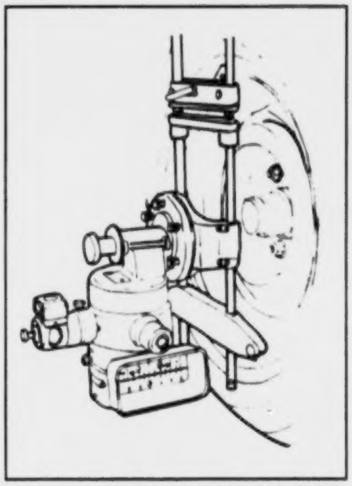
NOTE: Most static alignment machines use light beams to measure alignment angles. Older types project light beams onto special screens which have gauges or charts printed on them. On newer types, the light beam angle is converted to an electronic signal, and the angle reading is displayed on a computer screen.

mechanical gauge — Measures caster, camber, and steering axis inclination by using bubble-level indicators

NOTE: Some mechanical gauges are magnetically mounted to the wheel hub (Figure 5), and others are mounted to the wheel rim (Figure 6). Newer cars do not have hubs with machined surfaces that accommodate mechanical gauges, therefore, mechanical gauges are no longer commonly used.

EXAMPLE:

FIGURE 5



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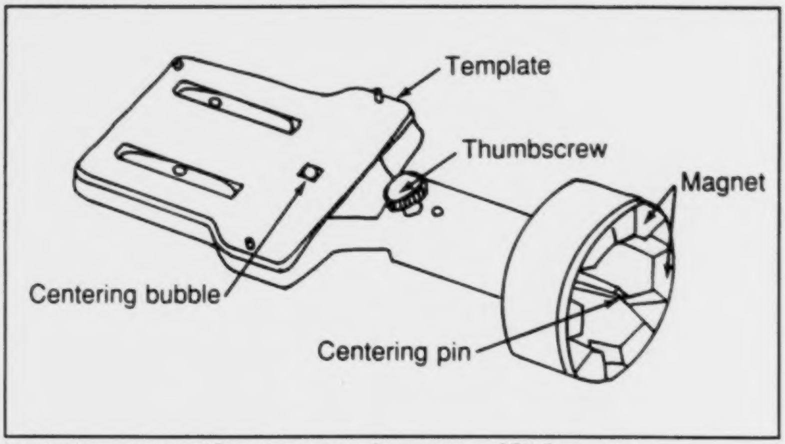
EXAMPLE:

FIGURE 6

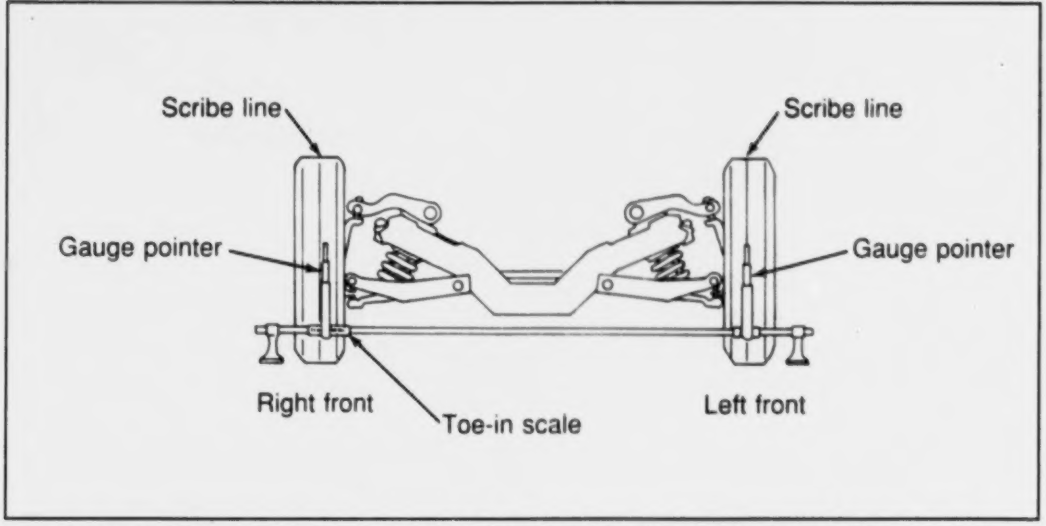

Template
Thumbscrew
Magnet
Centering bubble
Centering pin

Used with permission of Bear Automotive. A company of SPX Corporation.

mechanical toe gauge — Measures the amount of toe-in or toe-out by measuring the distance between lines drawn on the center of the tire treads (Figure 7)

EXAMPLE:

FIGURE 7


Scribe line
Scribe line
Gauge pointer
Gauge pointer
Right front
Toe-in scale
Left front

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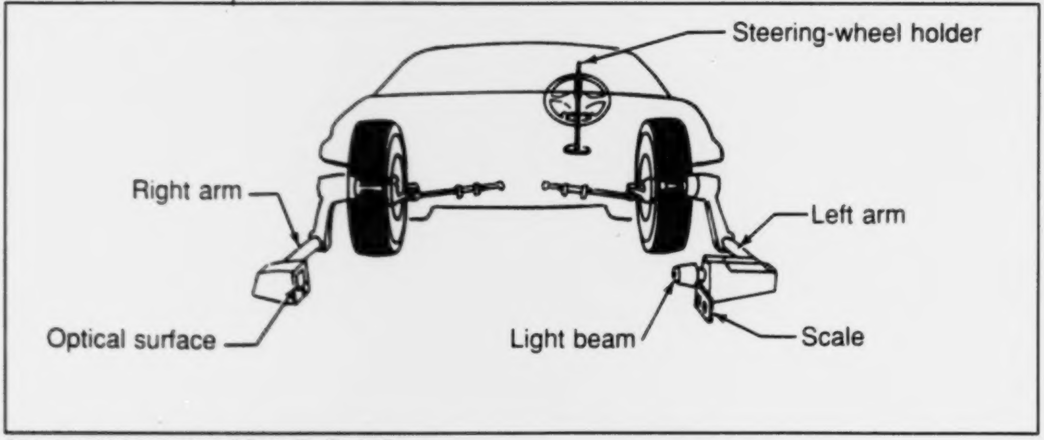
optical toe gauge — Measures toe setting by using a light beam, mirror, and scale (Figure 8)

NOTE: A light is mounted to one front wheel and projected at a mirror mounted to the other front wheel. The mirror reflects the light onto a scale; the reading on the scale lighted by the reflection is the toe setting. This gauge is used in conjunction with the mechanical gauges shown in Figures 6 and 7 for total alignment.

EXAMPLE:

FIGURE 8



Adapted with permission of Snap-On Tools Corp.

scuff gauge — Measures sideways drag of tires, indicating whether a vehicle has excessive toe-in or toe-out

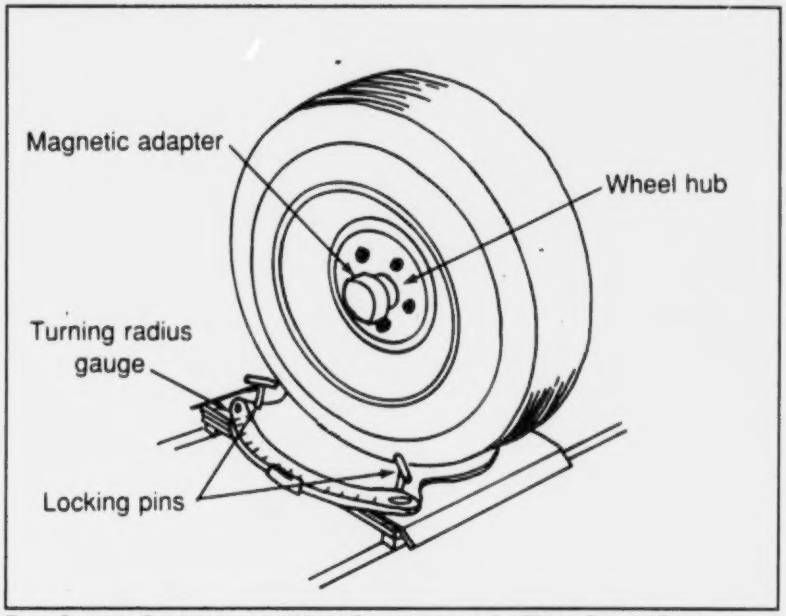
NOTE: Some scuff gauges can indicate whether alignment is needed, but none can actually measure the amount of misalignment.

turning radius gauge — Measures toe-out on turns by using turning devices with gauges under the front wheels; also used in conjunction with other devices to measure caster (Figure 9)

NOTE: The wheels are placed on gauges and are turned a specified amount in each direction; then the toe-out on turns of each wheel is measured.

EXAMPLE:

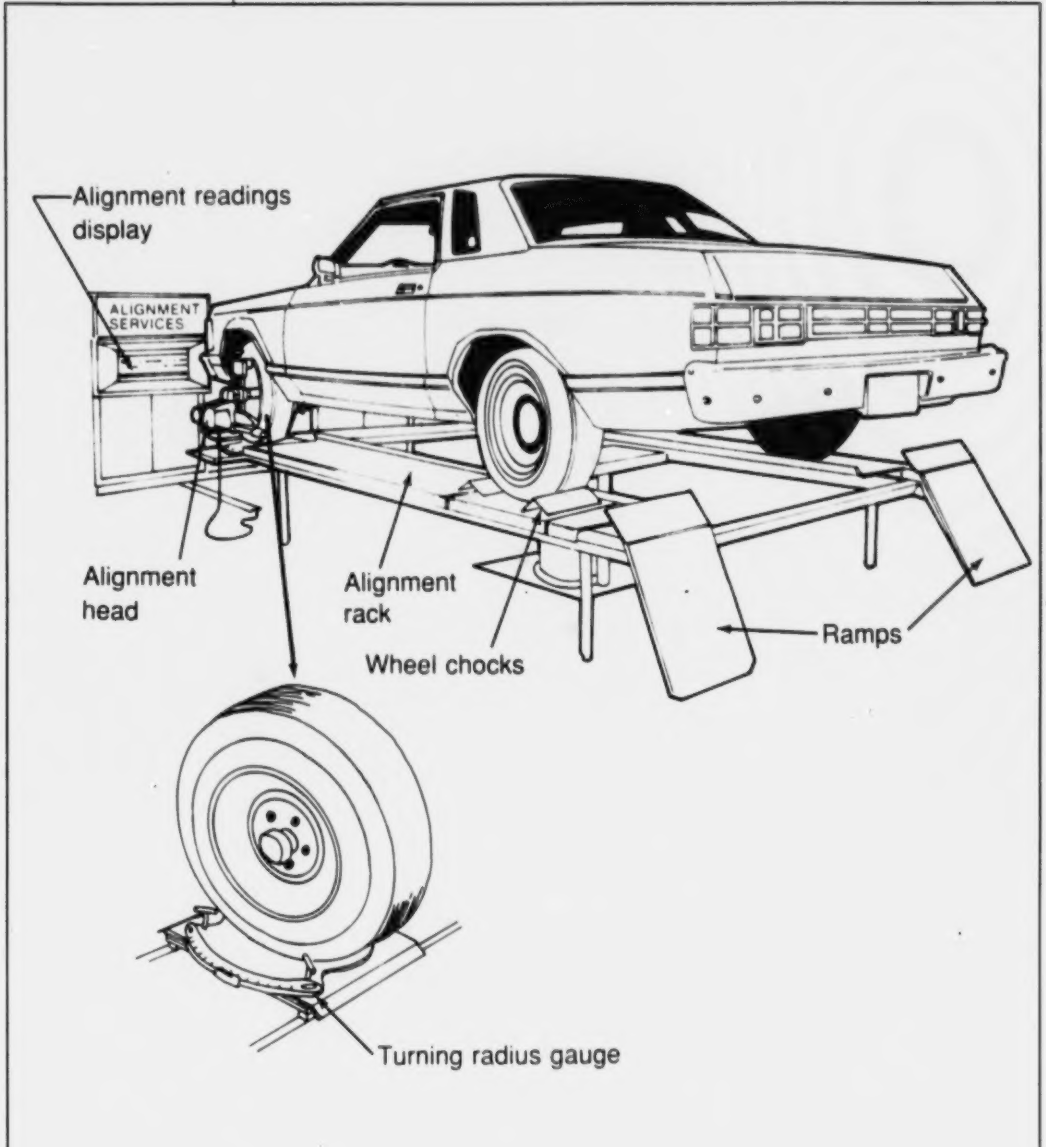
FIGURE 9


Magnetic adapter
Wheel hub
Turning radius gauge
Locking pins

From *Steering, Suspension, and Wheel Service, Unit 4*, © 1980 by State of Florida Department of State. Used with permission of Florida Department of State.

OBJECTIVE 6 **Identify the parts of a wheel alignment machine.** (Figure 10)

FIGURE 10


Alignment readings display
ALIGNMENT SERVICES
Alignment head
Alignment rack
Wheel chocks
Ramps
Turning radius gauge

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METHODS OF ADJUSTING WHEEL ALIGNMENT

There are different types of alignment adjustments for different kinds of suspension systems. Types of adjustments for the same type of suspension can vary too. Some of the more common methods of adjustments include using or adjusting:

- Shims
- Slots or elongated bolt holes
- Cam bolts (eccentrics)
- Strut rods

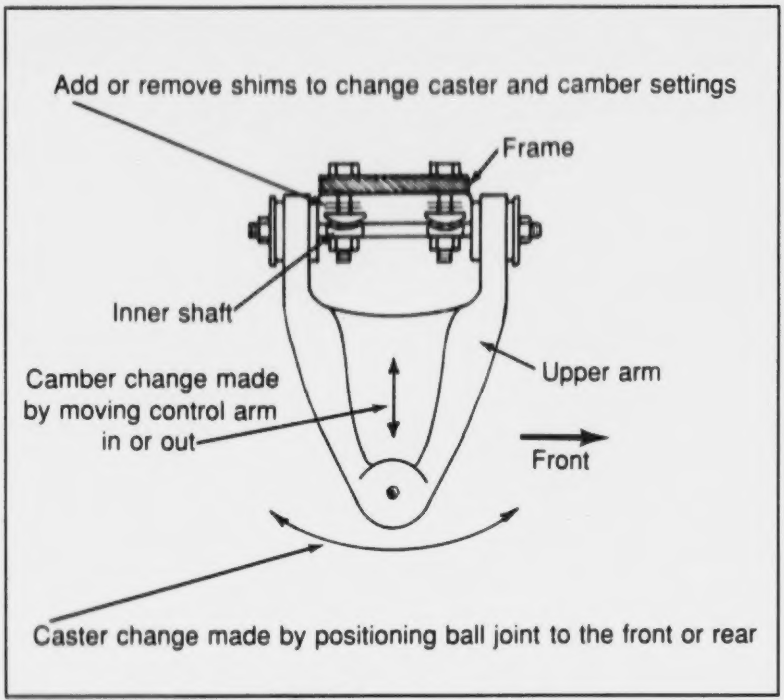
It is important that a steering and suspension technician understand basic alignment adjustments using these types of adjustments. Each of these adjustment methods will be discussed in this supplement.

SHIMS

Shims are used to adjust caster, camber, and toe. However, it is very unlikely that all three adjustments on the same vehicle will be adjusted using shims. On some suspensions, shims are used to adjust both camber and caster, and on others they are used to adjust only camber or toe.

Shims are added or removed to change caster and/or camber angles. Adjustments with shims are made on the upper control arms of short-and-long-arm suspension systems. The position of the ball joint is changed—thereby changing caster and camber angles—by adding or removing shims. This type of adjustment is shown in Figure 1 on the next page.

FIGURE 1


Add or remove shims to change caster and camber settings
Frame
Inner shaft
Upper arm
Camber change made by moving control arm in or out
Front
Caster change made by positioning ball joint to the front or rear

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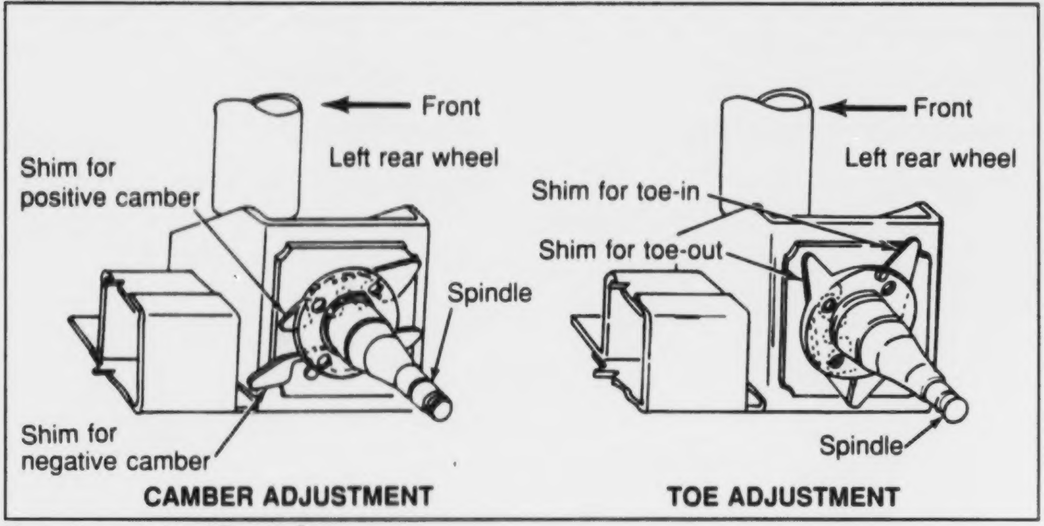
Adjustments of the rear wheels of some four-wheel drive vehicles and many front-wheel drive vehicles are made by adding shims between the axles and the spindles. Shims are added behind the spindle to change alignment angles. Figure 2 shows two adjustments for a rear wheel of a front-wheel drive vehicle. Adding shims to the upper side causes a positive change in camber; adding shims to the lower side causes a negative change in camber. Toe adjustments are similar; shims are added to either the front or back of the spindle to change the toe setting.

FIGURE 2


Front
Left rear wheel
Shim for positive camber
Spindle
Shim for negative camber
CAMBER ADJUSTMENT
Front
Left rear wheel
Shim for toe-in
Shim for toe-out
Spindle
TOE ADJUSTMENT

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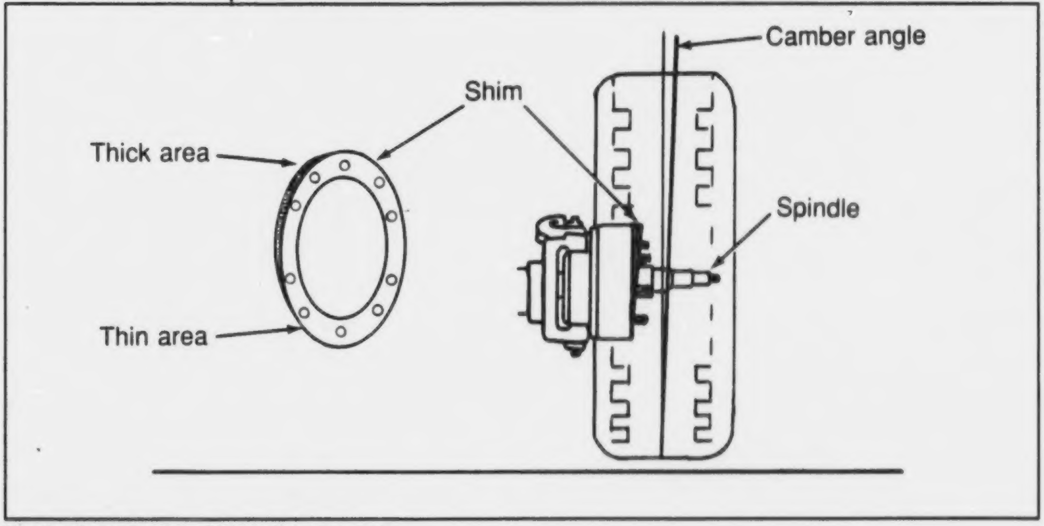
Circular-shaped shims are sometimes used on the wheels of four-wheel drive vehicles. As you can see in Figure 3 below, the thickness of a shim varies at different parts of the circle. Rotating the shim to different positions produces different angle changes. Shim manufacturers will give specifications for the correct placement of such shims.

FIGURE 3


Camber angle
Shim
Thick area
Spindle
Thin area

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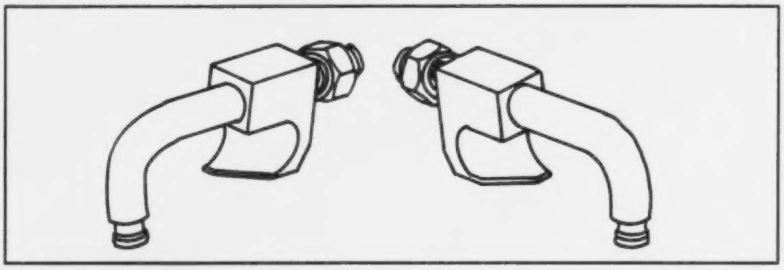
SLOTS

Some-suspension components have slots or elongated bolt holes that allow alignment changes to be made. Bolts are simply loosened, the part is slightly repositioned so that the alignment angle(s) is correct, and then the bolts are tightened. This type of adjustment method is used for adjusting caster and camber.

On some vehicles with short-and-long-arm suspensions, the inner shaft of the upper control arm is bolted to slots in the frame. Caster and camber are adjusted by loosening these bolts and moving the upper control arm by sliding the inner shaft in or out. To make this adjustment on some vehicles, special tools, such as those shown in Figure 4, have to be used.

FIGURE 4



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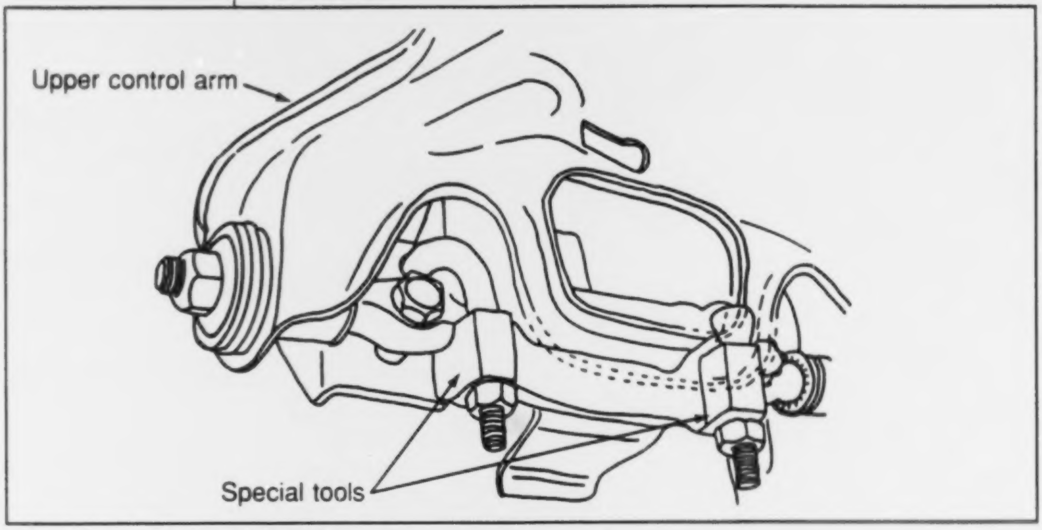
When using this particular tool, adjustments are made by turning the hex head of the tool. How much the hex head of the tool should be turned to achieve a particular change in the caster or camber angle is specified in tables in the manufacturer's service manual. Figure 5 shows an upper control arm being adjusted using these special tools.

FIGURE 5



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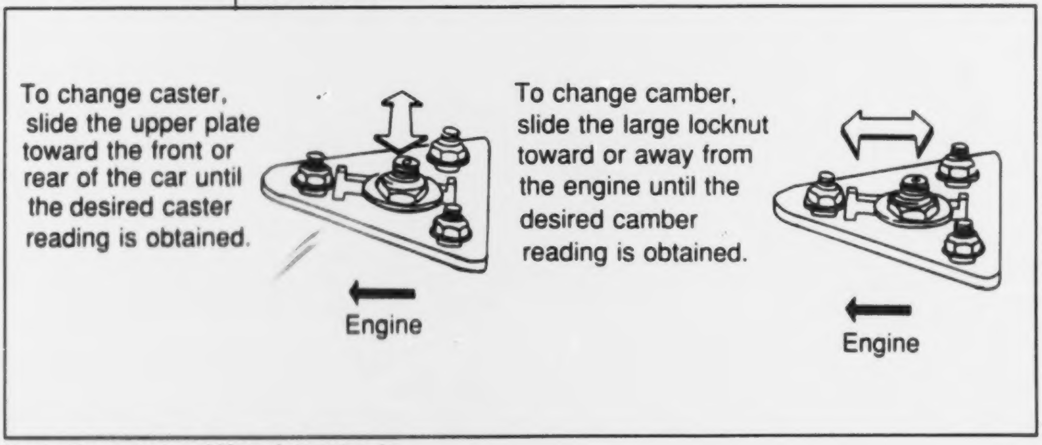
Caster and camber on some vehicles with MacPherson struts are adjusted by shifting the strut assembly at the upper mounting. Slots in the upper fender mounting (or in the upper plate of a special adjustment kit) allow the strut to be moved after certain bolts are loosened. Figure 6 shows how the bolt connected to the strut assembly can be shifted to change caster and camber settings. Another method involves the rotation of the strut assembly.

FIGURE 6



To change caster, slide the upper plate toward the front or rear of the car until the desired caster reading is obtained.

To change camber, slide the large locknut toward or away from the engine until the desired camber reading is obtained.

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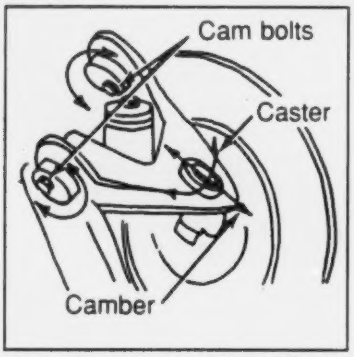
CAM BOLTS

Another method for adjusting camber and/or caster involves the use of eccentric cams attached to cam bolts. Cam bolt adjustments are used with short-and-long-arm suspension systems and MacPherson strut suspension systems.

Cam bolt adjustments for short-and-long-arm suspension systems vary. Most adjustments for vehicles with short-and-long-arm suspensions are made at the upper control arms. Caster and camber adjustments made at the uppper control arms are shown in Figure 7. Turning cam bolts the same amount in the same direction changes the camber angle. Turning the bolts different amounts in the same direction or turning them in opposite directions changes the caster setting.

FIGURE 7



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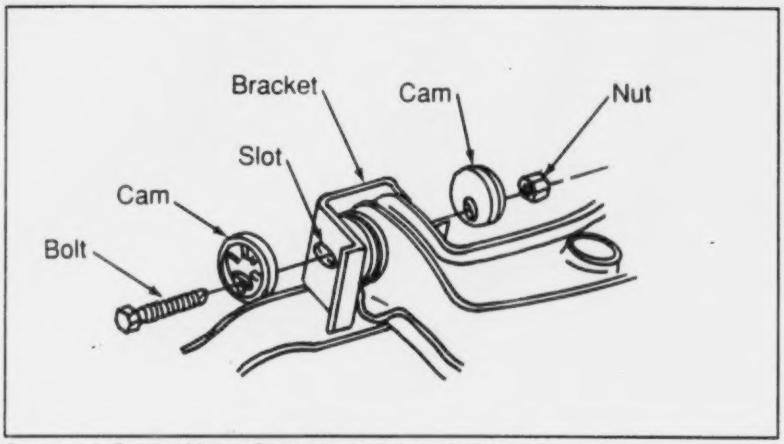
On systems which have a coil spring on the upper control arm and have a lower control arm that attaches to the frame at only one point, adjustments are made by turning a cam bolt located at the lower control arm bushing.

Many vehicles with short-and-long-arm suspension systems which cannot normally be adjusted can be adapted by installing a special alignment service kit. Figure 8 shows one type of adjustment kit using cam bolts.

FIGURE 8



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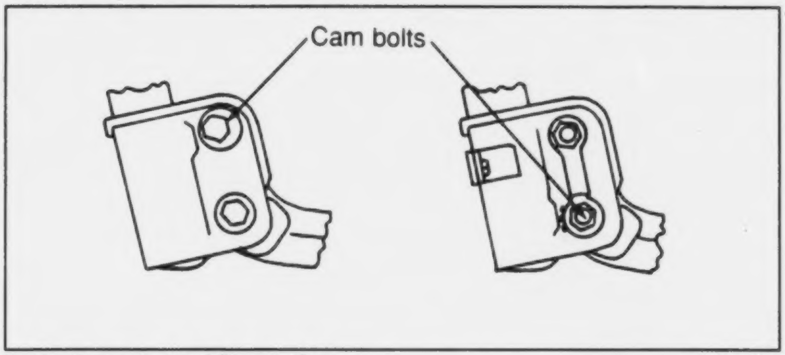
Cam bolts are sometimes used to make camber adjustments on vehicles with MacPherson struts. One of the bolts connecting the strut assembly to the lower steering control arm is a cam bolt. (Figure 9) By turning the bolt, camber can be changed.

FIGURE 9



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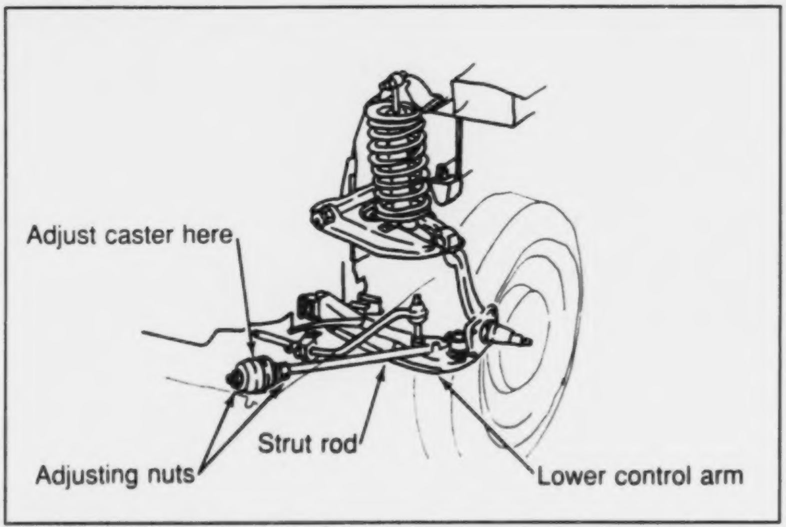
STRUT RODS

Adjustments for caster angle can be made on some short-and-long-arm and MacPherson strut suspensions by changing the length of the strut rod. By adjusting the length of the strut rod, the position of the lower ball joint is changed, thereby changing the caster angle.

On vehicles having short-and-long-arm suspension with the lower control arm attaching to the frame at one point, caster is often adjusted with the strut rod. Usually there are special adjusting nuts that are turned to increase or decrease the effective length of the strut rod. Figure 10 shows the suspension of one type of vehicle using this method of adjustment.

FIGURE 10



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Some vehicles with MacPherson struts have strut rods, and on these, caster is adjusted in a manner similar to that described above.

There are other types of adjustments, however those presented in this supplement are the most common types. Always refer to the vehicle manufacturer's service manual to see what adjustment methods are used to correct wheel alignment.

Alignment Specifications Table

FRONT WHEEL ALIGNMENT (Curb Height with ½ Tank of Fuel)

Vehicle	**Item**	**Alignment Factors**		
		Nominal	**Minimum**	**Maximum**
Lincoln Town Car, Ford Crown Victoria, Mercury Grand Marquis	Caster	+ 3.0	+ 2-¼	+ 4.0
	Camber	+ ½	– ¼	+ 1-¼
	Toe	INCHES + 0.063″	INCHES – 0.063″	INCHES + 0.188″
		DEGREES + 0.125	DEGREES – 0.125	DEGREES + 0.375
		FRACTIONAL INCHES + 1⁄16″	FRACTIONAL INCHES – 1⁄16″	FRACTIONAL INCHES + 3⁄16″
		MILLIMETER + 1.6 mm	MILLIMETER – 1.6 mm	MILLIMETER + 4.8 mm

Maximum caster and camber difference between wheels (left minus right) to be within – ¾ to + ¾ with caster and camber set to specifications.

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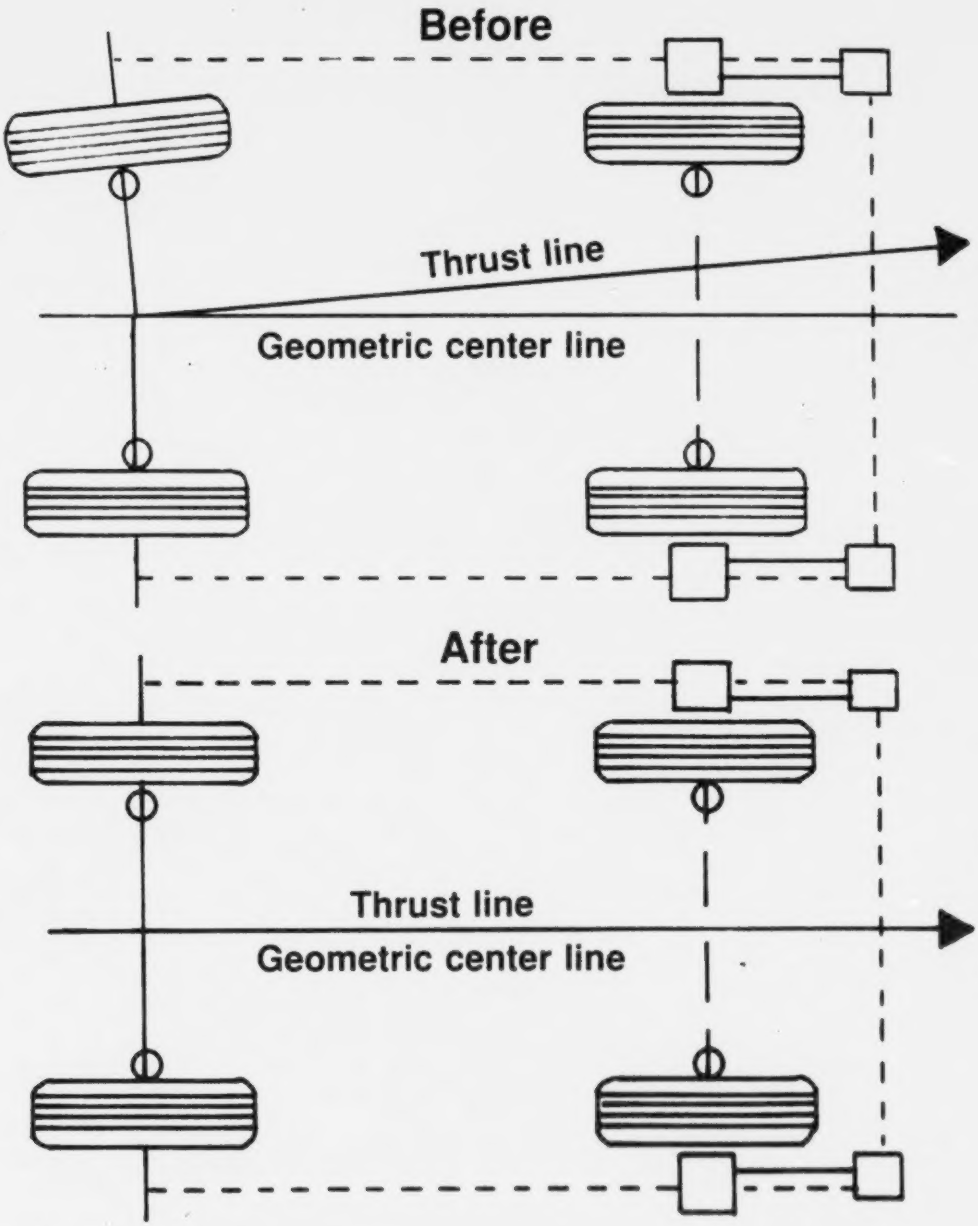
Factors in Setting Toe— Adjustable Rear Toe


Before
Thrust line
Geometric center line
Front
After
Thrust line
Geometric center line
Front

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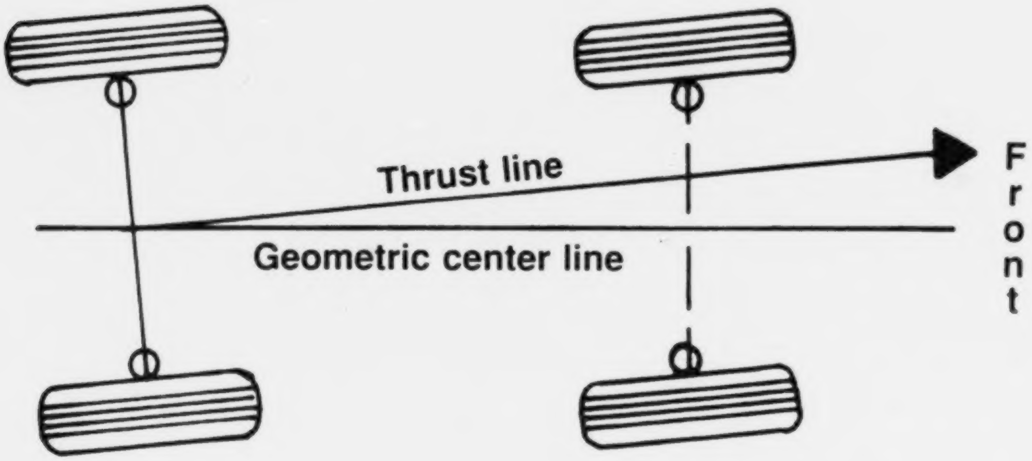
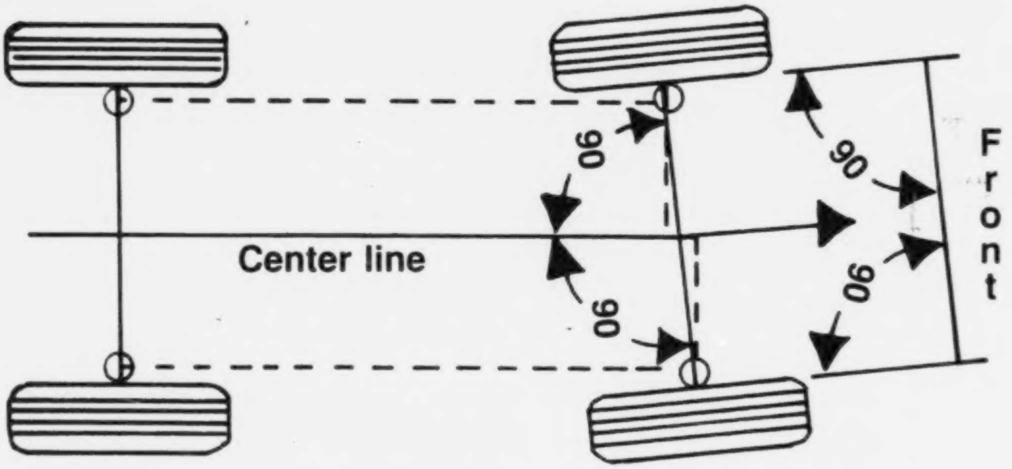
Factors in Setting Toe— Nonadjustable Rear Toe


Thrust line
Geometric center line
Front


90
90
90
90
Center line
Front

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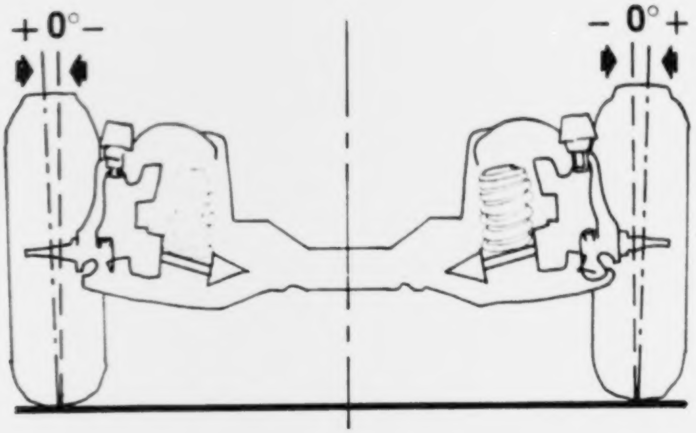
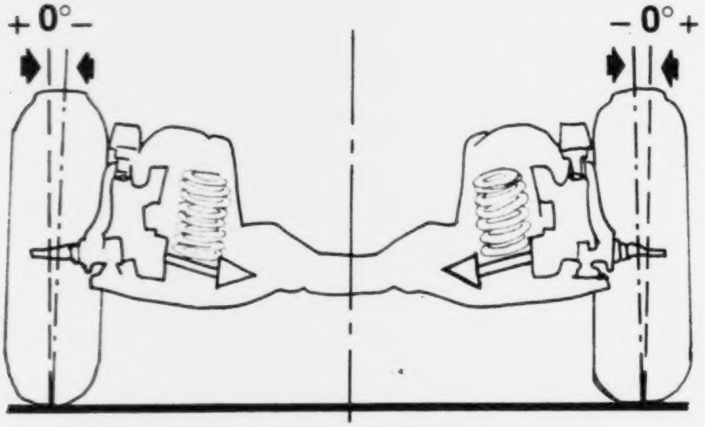
Camber

Positive Camber



Negative Camber



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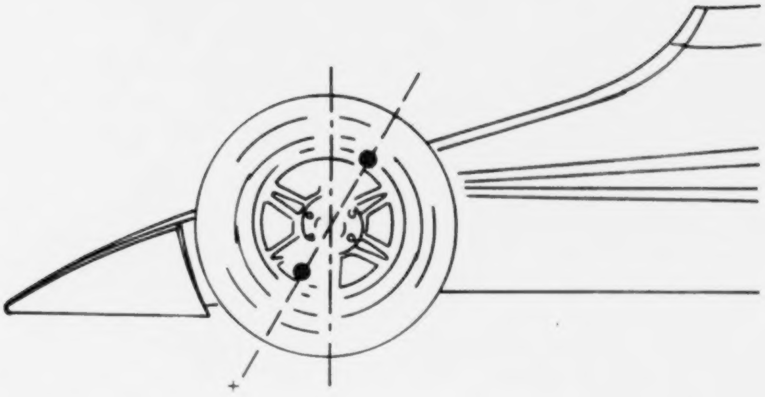
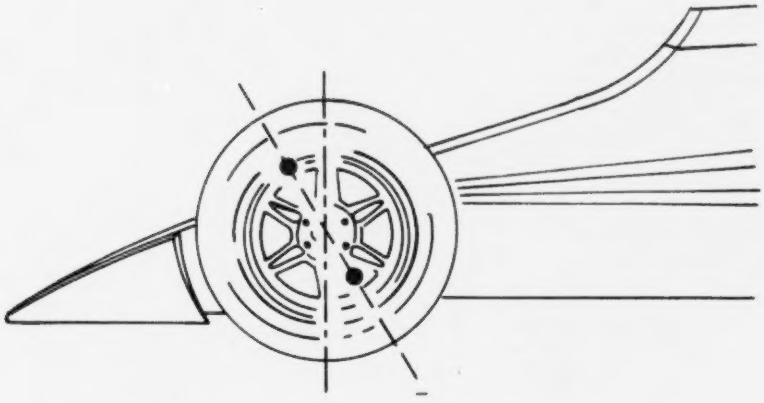
Caster

Positive Caster



Negative Caster



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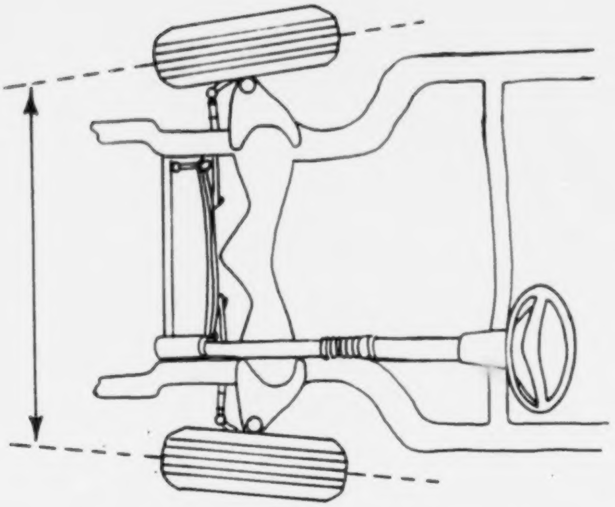
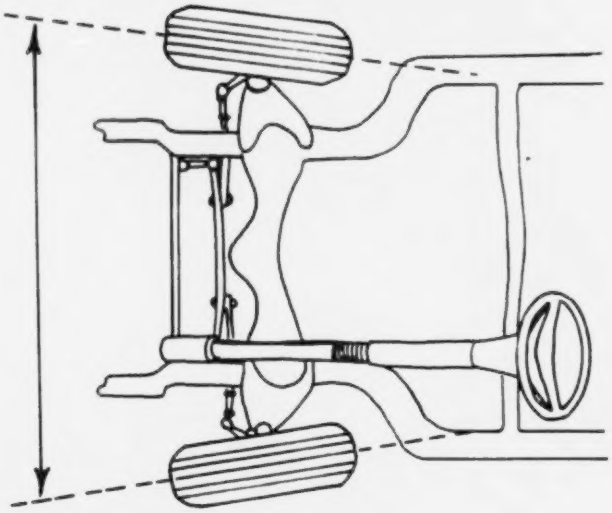
Toe

Toe-In



Toe-Out



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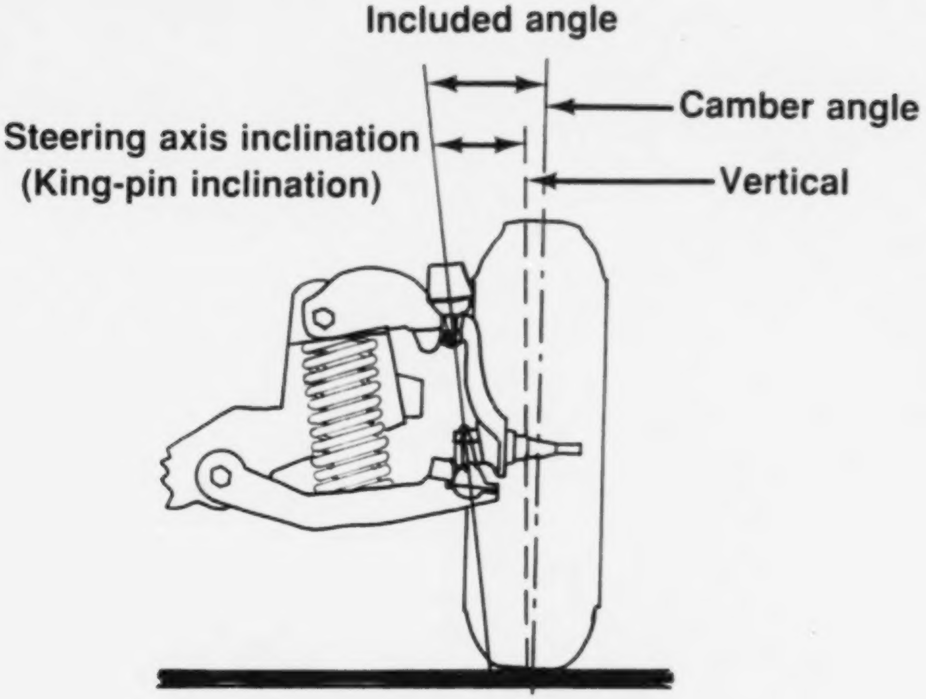
Steering Axis Inclination (SAI)


Included angle
Camber angle
Steering axis inclination
(King-pin inclination)
Vertical

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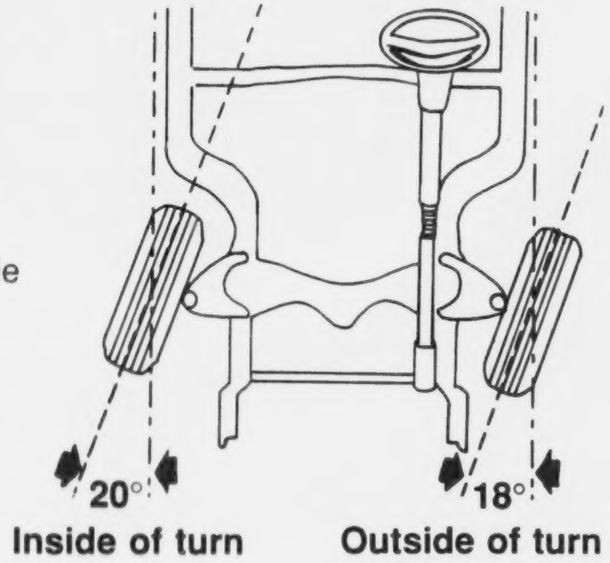
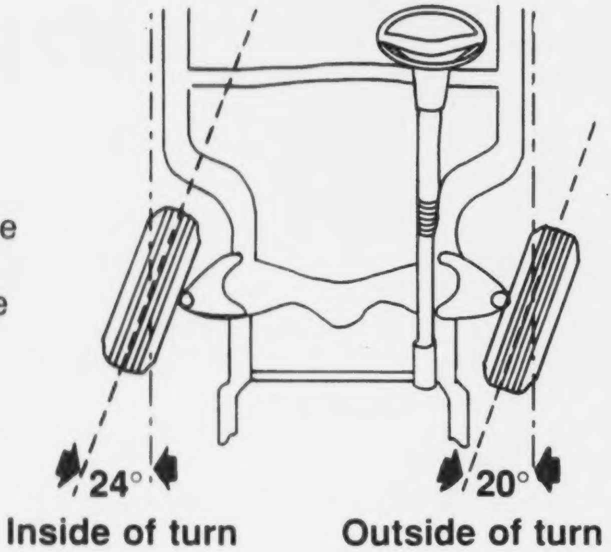
6[illegible]

Toe-Out on Turns and Turning Angle

Most car manufacturers specify the turning angle of the wheel on the outside of the turn, when the wheel on the inside is turned out 20°. Therefore, the specified angle will be less than 20°.


20°
Inside of turn
18°
Outside of turn

Some car manufacturers specify the turning angle of the wheel on the inside of the turn, when the wheel on the outside is turned in 20°. The specified angle will be more than 20°.


24°
Inside of turn
20°
Outside of turn

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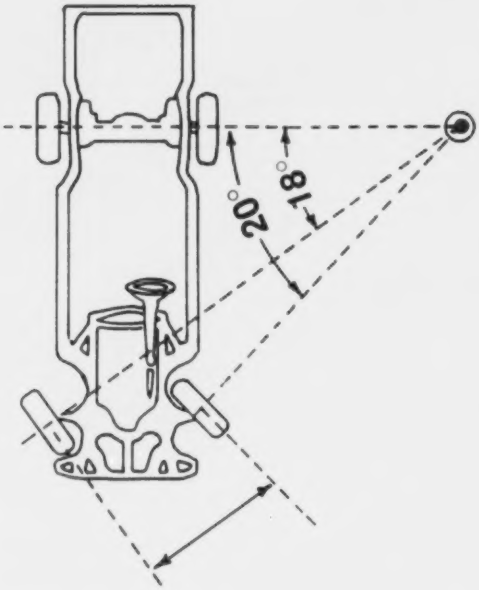
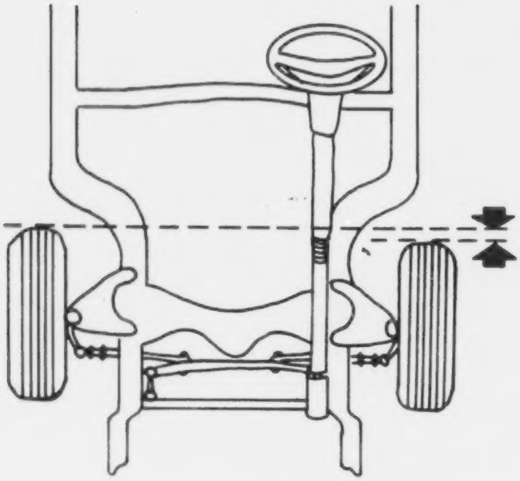
Toe-Out on Turns and Turning Angle

The turning angle must be within 1½° of specifications from side to side. If it isn't, a bent steering arm is indicated and must be replaced, not repaired.



Set-back is a condition in which one wheel is rearward of the other. Set-back will not affect handling unless it is extreme, generally the result of collision damage.



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ACTIVITY SHEET 1

ADJUST WHEEL ALIGNMENT

VI

NAME ______________________________ SCORE ________

ANSWER GENERAL QUESTIONS ABOUT WHEEL ALIGNMENT ADJUSTMENTS

INTRODUCTION

To become certified as a steering and suspension technician, you must pass a test on the steering and suspension systems compiled by the National Institute for Automotive Service Excellence. The certification test covers all aspects of the vehicle's steering and suspension systems. This activity sheet only contains questions about wheel alignment adjustments, but the questions are realistic and are similar in content and style to those found on the actual ASE certification test.

DIRECTIONS

Read each of the following study questions twice. The second time you may notice a key word that you overlooked the first time. Every word in a question is important and can provide a clue to the right answer. Select the answer that is *most* correct, and write its letter in the answer blank.

After you have completed this activity sheet, get together with a group of your classmates, and use the answer key to check your answers. Discuss the questions and their correct answers, paying particular attention to those that were answered incorrectly. Review any information that you do not understand.

______1. Technician A says tracking cannot be measured and adjusted using an alignment machine for a two-wheel alignment. Technician B says using a ruler is the best way to obtain the most accurate tracking measurements. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______2. Which of the following statements about checking and adjusting caster is **not** correct?

A. Shims should be removed and added in equal amounts
B. The caster angles of a vehicle with an unlevel frame should be corrected following the vehicle manufacturer's instructions
C. Special tools are required to adjust caster on some vehicles
D. A vehicle that normally carries a heavy load should be unloaded before caster angles are measured

______3. Technicians A and B are discussing camber adjustments. Technician A says camber is adjustable on almost every vehicle. Technician B says camber on some vehicles is not adjustable, but adjustment kits can be installed to correct camber settings. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______4. Technicians A and B are discussing toe adjustment. Technician A says if the steering knuckle is attached to the rear of the spindle assembly, the tie-rod assemblies must be lengthened to increase toe-in. Technician B says if the steering knuckle is attached to the front of the spindle assembly, the tie-rod assemblies must be shortened to decrease toe-in. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

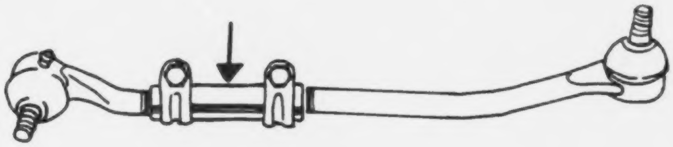
______5. Which of the following best defines *included angle*?

A. SAI angle minus caster angle
B. Camber angle minus SAI angle
C. SAI angle plus camber angle
D. SAI angle minus camber angle

______6. Technicians A and B are discussing wheel alignment equipment. Technician A says front and rear pads are interchangeable. Technician B says they are not interchangeable because the front pads rotate and the rear pads do not. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

______7. In the illustration below of a tie-rod assembly, to what part is the arrow pointing?



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A. Outer tie-rod end
B. Inner tie-rod end
C. Cam bolt adjuster
D. Adjuster sleeve

______8. Technicians A and B are discussing caster adjustment on vehicles with short-and-long-arm suspensions. Technician A says caster can adjusted by adding and removing shims at the upper control arm. Technician B says caster can be adjusted at the strut rod on some vehicles with this type of suspension. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

For items 9-10, refer to the alignment specifications below:

FRONT WHEEL ALIGNMENT SPECIFICATIONS

Toe-In	3 ± 3mm (0.12 ± 0.12 in.)
Camber	0.28° ± 0.75°
Caster	1.22° ± 0.75°
Left/Right Difference:	
Camber	0.5° max
Caster	0.67° max
Steering Angle:	
Inner	36.44° F2 T/C A/T: 33.87°
Outer	30.99° F2 T/C A/T: 29.34°
King Pin Angle (SAI)	12.78°

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______9. Technicians A and B are discussing the caster specifications presented in the table above and the caster readings of the vehicle. The caster reading for the right front wheel is 0.57° and the reading for the left front wheel is 1.48°. Technician A says the readings are within specifications. Technician B says the readings are **not** within specifications. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

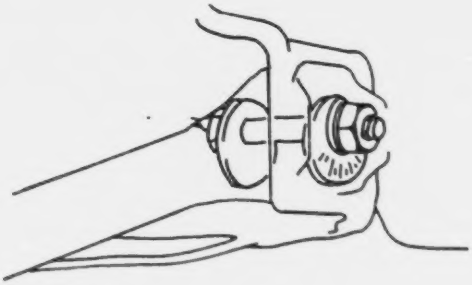
_____10. Technicians A and B are discussing the camber specifications presented in the table above and the camber readings of the vehicle. The camber reading for the right front wheel is -0.28° and the reading for the left front wheel is 0.12°. Technician A says the readings are within specifications. Technician B says the readings are **not** within specifications. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____11. Technician A says the purpose of the SAI angle is to decrease the need for excessive caster. Technician B says the SAI angle is equal to the camber angle plus the included angle. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____12. One method of alignment adjustment is illustrated below. Which of the following adjustment methods is shown?



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A. Slotted holes
B. Shims
C. Cam bolts
D. Adjuster nut

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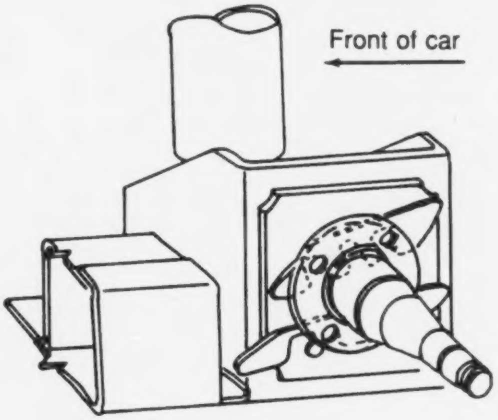
_____13. Technician A says if toe-out on turns is not within specifications, it cannot be adjusted to specifications. Technician B says if toe-out on turns is not within specifications, the steering knuckle assembly could be bent. Who is correct?

A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____14. Technicians A and B are discussing the illustration below of the shim installation for a left rear wheel. Technician A says such a shim installation will cause the caster setting to be more positive. Technician B says it will cause the camber to be more negative. Who is correct?



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A. Technician A
B. Technician B
C. Both A and B
D. Neither A nor B

_____15. Which of the following can be used to adjust caster?

A. Slotted holes
B. Shims at strut rod connections
C. Cam bolts
D. All of the above

ACTIVITY ANSWERS

ADJUST WHEEL ALIGNMENT

VI

ACTIVITY SHEET 1

1. A
2. A
3. C
4. A
5. C
6. B
7. D
8. C
9. B
10. A
11. D
12. C
13. C
14. B
15. D

ASSIGNMENT SHEET 1

ADJUST WHEEL ALIGNMENT

VI

NAME ______________________________ SCORE ________

OBJECTIVE 7

Interpret alignment specifications to analyze alignment angle readings.

INTRODUCTION

It is important that the steering and suspension technician be able to interpret alignment machine readings. Wheel alignment specifications are found in service manuals and other reference materials. Some computerized test equipment is programmed with specifications. Service bulletins update specifications and should be consulted. The technician must be able to use these resources correctly to analyze alignment angle readings. By doing so, he or she will be able to make alignment adjustments correctly.

Vehicle manufacturers' service manuals and other professional manuals provide alignment specifications and indicate which alignment angles are adjustable. In many manuals, alignment specifications are presented in a table. In others, alignment specifications are included within the outlined adjustment procedure. Sometimes information for a particular angle will be presented in a chart. These charts show needed changes to specifications for variable alignment settings. For example, the exact caster setting for some trucks depends on the vehicle's ride height, and a chart shows what the different caster settings are for different heights.

However the specifications are presented, they usually include information for caster, camber, and toe for front wheels and for camber and toe for adjustable rear wheels. For each angle, a specified setting and a minimum and maximum setting are given. This specified setting is usually called the *nominal*, *preferred*, or *setting* specification. Any adjustments should be made so that angles will be equal to these values. Also given is a range of settings for proper alignment and vehicle operation. This range is often indicated with minimum and maximum settings and is sometimes called the *checking range* or the *service checking range*.

Some alignment specifications include a maximum variation between the settings of the wheels. It is important to pay attention to this information and compare the difference between the readings of both wheels with this maximum variation. It is possible that the settings of both wheels could be within the specified checking range but not within the given range of variation between wheels. If side-to-side variation is not specified, the accepted procedure allows ½ degree maximum variation from side-to-side for caster or camber.

Alignment specifications differ, too, in the way measurements are presented. All angle measurements are given in degrees, but a portion of a degree can be represented with fractions or decimals. Since these specifications can be either negative (–) or positive (+), it is important to be able to add and subtract negative and positive numbers. If no sign is given, the number is positive. Toe specifications are given in degrees or can be presented in inches or millimeters.

This assignment sheet will give you practice in interpreting alignment specification information and determining whether alignment readings are within a manufacturer's specified settings.

DIRECTIONS

Study each of the following alignment specifications tables and read the vehicle alignment readings for each situation. Then write the correct answers in the blanks.

For items 1-3, refer to the following alignment specifications:

ALIGNMENT SERVICE DATA	
TOE	
Front 0 ± 2 mm (–0.079 ± 0.078 in)	
Rear 2 ± 2 mm (0.079 ± 0.079 in)	
CAMBER	
Front	0 ± 1°
Rear	0°
CASTER	
Front 3° ± 2° (16 mm 0.65 in)	
TURNING ANGLE	
Inside	38°
Outside	32°
SIDE SLIP LIMIT:	
Front is less than 3 mm/m (0.118 in/3 ft)	
Rear is 2 ± 3 mm/m (0.079 ± 0.118 in/3 ft)	

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1. The caster reading for the left front wheel is 1°, and the reading for the right front wheel is 4°.

   A. Is left wheel caster within specifications?

   ____

   B. Is right wheel caster within specifications?

   ____

2. The camber reading for the left front wheel is –½°, and the reading for the right front wheel is –1½°.

   A. Is left wheel camber within specifications?

   ____

   B. Is right wheel camber within specifications?

   ____

3. The camber reading for both rear wheels is –½°.

   A. Is rear wheel camber within specifications?

   ____

   B. What camber reading(s) for the rear wheels is acceptable?

   ____

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For items 4-6, refer to the alignment specifications presented below:

Alignment Factors	Alignment Specifications				
	Nominal	Preferred Setting	Checking Range		Max. Variation Between Wheels
			Min.	Max.	
Caster	3.5°	4.0°	2.5°	4.5°	0.75 degrees
Camber	0.2°	0.2°	-0.3°	+0.7°	0.75 degrees
Toe In	—	0.8 mm (1/32 inch) IN	2.5/mm (3/32 inch) OUT	4.0 mm (5/32 inch) IN	—

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4. The caster reading for the left front wheel is 2.5°, and the reading for the right front wheel is 3.5°.

   A. Is left wheel caster within specifications?

   ____

   B. Is right wheel caster within specifications?

   ____

   C. Considering the caster readings for both wheels, is caster adjustment necessary? Why or why not?

   ____

   ____

5. The camber reading for the left front wheel is 0.2°, and the reading for the right front wheel is 0.5°.

   A. Is left wheel camber within specifications?

   ____

B. Is right wheel camber within specifications?

____

C. Considering the camber readings for both wheels, is camber adjustment necessary? Why or why not?

____

____

6. The reading for toe-in is 0.9 mm.

A. Is toe within specifications?

____

B. Should toe be adjusted? Why or why not?

____

____

For items 7-9, refer to the alignment specifications presented below:

WHEEL ALIGNMENT SPECIFICATIONS

OPERATION	SERVICE CHECKING	SERVICE SETTING
MANUAL ST. CASTER	+ 1.0° ± 1.0° (B)	+ 1.0° (A)
POWER ST.	+ 3.0° ± 1.0° (B)	+ 3.0° (A)
CAMBER	+ .5° ± .8° (B)	+ .5° (A)
	+ .8° ± .8° (B)	+ .8° (A)
TOE (FRONT)	+ .15° ± .1° (C)	+ .15° (C)

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7. The caster reading for the left front wheel is 1.75°, and reading for the right front wheel is 0.5°.

   A. If this vehicle has manual steering, is left wheel caster within specifications?

   ____

   B. If this vehicle has manual steering, is right wheel caster within specifications?

   ____

   C. If this vehicle has power steering, is left wheel caster within specifications?

   ____

   D. If this vehicle has power steering, is right wheel caster within specifications?

   ____

   E. Within what range must caster readings for vehicles with power steering fall?

   ____

8. The camber reading for the left front wheel is -0.2°, and the reading for the right front wheel is 0.8°.

   A. Is left wheel camber within specifications?

   ____

   B. Is right wheel camber within specifications?

   ____

   C. Considering the camber readings for both wheels, is camber adjustment necessary? Why or why not?

   ____

   ____

9. The toe reading is 0.11°.

   A. Is toe within specifications?

   B. Within what range must the toe reading fall?

For items 10-12, refer to the alignment specifications presented below:

SPECIFICATIONS

Model	Caster (F)		Camber		Toe-In (D) (per wheel)	
	Check (C)	Set (B)	Check (C)	Set (B)	Check (D)	Set
C1, 2, 3	3.75° ± 2.0°	3.75° ± 1.0°	5° ± 1.0°	.50° ± .50°	.24° ± .20°	.24°
K1, 2	3.0° ± 2.0°	3.0° ± 1.0°	.65° ± 1.0°	.65° ± .50°	.24° ± .20°	.24°
K3	3.0° ± 2.0°	3.0° ± 1.0°	.50° ± 1.0°	.50° ± .50°	.24° ± .20°	.24°

Note: Vehicle must be jounced 3 times before checking alignment to eliminate false geometry readings.

(A) Front suspension (Z) dimension and rear suspension (D) dimension are held as indicated in the "Trim Heights" chart.
(B) Left and right side to be equal within .50°.
(C) Left and right side to be equal within 1.0°.
(D) Toe-in on the left and right side to be set separately per wheel. The steering wheel must be held in a straight ahead position within ± 5.0°.
(E) For service, use #15538596 adjustment kit.
(F) Caster angle must be corrected to the level frame angle.

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10. A model C1 pickup has caster readings of 4.75° for the left front wheel and 3.0° for the right front wheel.

    A. Are these caster readings within specifications? Why or why not?

B. What is the caster setting range for this pickup?

____

11. A model K2 pickup has camber readings of -1.65° for the left front wheel and 0.65° for the right front wheel.

A. Is left wheel camber within specifications?

____

B. Is right wheel camber within specifications?

____

C. If camber is adjusted and the new readings are 0.65° for the left front wheel and 1.05° for the right front wheel, are the new settings within specifications?

____

12. A model K3 pickup has toe-in reading of 0.45°.

A. Is toe-in within specifications?

____

B. What is the acceptable range for toe-in?

____

For items 13-15, refer to the alignment specifications presented below:

FRONT WHEEL ALIGNMENT	**Acceptable Alignment Range**	**Preferred Setting**
CAMBER—All Models	–0.2° to + 0.8° (–1/4° to + 3/4°)	+ 0.3° (+ 5/16°)
TOE—All Models		
Specified in Inches	7/32" **IN** to 1/8" **OUT**	1/16" **IN** ± 1/16"
Specified in Degrees	.4° **IN** to .2° **OUT**	0.1° **IN** ± .1°

REAR WHEEL ALIGNMENT	**Acceptable Alignment Range**	**Preferred Setting**
CAMBER		
L Body	–1.3° to –0.2° (–1 1/4° to –1/4°)	–.75° ± .5° (1/2°)
K, E, G, H Bodies	–1.3° to + 3° (–1 1/4° to + 1/4°)	–.5° ± .5° (1/2°)
TOE*		
L Body		
Specified in Inches	3/16" **OUT** to 13/32" **IN**	3/32" **IN**
Specified in Degrees	0.4° **OUT** to 0.8° **IN**	0.2° **IN**
K, E, G, H Bodies		
Specified in Inches	5/16" **OUT** to 5/16" **IN**	0" ± 1/8"
Specified in Degrees	0.60° **OUT** to 0.60° **IN**	0° ± .25°

*TOE OUT when backed on alignment rack is TOE IN when driving.

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13. The camber reading for the left front wheel is –1/2°, and the reading for the right front wheel is 1/2°.

    A. Is left wheel camber within specifications?

    ____

    B. Is right wheel camber within specifications?

    ____

14. The toe-in reading for the front wheel is 1/16".

    A. Is toe within specifications?

    ____

    B. What is the preferred setting range for toe?

    ____

15. A G-body vehicle has camber readings of −1° for the left rear wheel and 1¼° for the right rear wheel.

A. Is left wheel camber within specifications?

____

B. Is right wheel camber within specifications?

____

ASSIGNMENT ANSWERS

ADJUST WHEEL ALIGNMENT

VI

ASSIGNMENT SHEET 1

1. A. Yes
   B. Yes

2. A. Yes
   B. No

3. A. No
   B. 0°

4. A. Yes
   B. Yes
   C. Yes; there is a 1° variation between wheels, and maximum variation allowed is 0.75°

5. A. Yes
   B. Yes
   C. No; there is a 0.3° variation between wheels, and the maximum variation allowed is 0.75°

6. A. Yes
   B. No; the 0.9 mm toe-in reading falls between the minimum and maximum values of the specified checking range

7. A. Yes
   B. Yes
   C. No
   D. No
   E. Between 2.0° and 4.0°

8. A. Yes
   B. Yes
   C. Yes; it exceeds the 5° variation between wheels

9. A. Yes
   B. 0.05° to 0.25°

10. A. No; there is a 1.75° variation between wheels, and the maximum variation allowed is 1.0°
    B. 2.75° to $^{4}/_{75}$°

11. A. No
    B. Yes
    C. Yes

12. A. No
    B. 0.04° to 0.44°

13. A. No
    B. Yes

14. A. Yes
    B. 1/16″ **IN** + 1/16″ or 0.1° **IN** + 0.1°

15. A. Yes
    B. No

JOB SHEET 1

ADJUST WHEEL ALIGNMENT

VI

OBJECTIVE 8A

Set up a wheel alignment machine for a two-wheel and a four-wheel alignment procedure.

INTRODUCTION

In order for any wheel alignment service procedure to be effective, the equipment used for alignment must be in good working condition and set up properly. It is very important that the steering and suspension technician have the skills necessary to prepare the wheel alignment machine for both types of wheel alignment service.

In many service situations, only the front wheels of a vehicle are aligned. However, alignment of all four wheels should be checked and adjusted if possible. It is especially important that all four wheels of four-wheel drive vehicles, front-wheel drive vehicles, and rear-wheel drive vehicles with independent rear suspension be checked.

Wheels can be aligned using either dynamic or static alignment machines. A dynamic alignment machine measures alignment angles while a vehicle's wheels are rotating; static alignment machines measure alignment angles with the wheels stationary. Either type of machine can be computerized. Some types have four alignment heads and can be used for four-wheel alignment; others have only two heads and are used for two-wheel alignment.

The set-up and operation of these machines varies; the technician must always consult the alignment machine manufacturer's manual. However, there are some general guidelines that should be followed whenever using alignment equipment, and these are listed below and on the following page.

Guidelines for using static alignment machines:

- Be sure the vehicle is centered on the alignment rack and the wheels are centered properly on the turntables.

  CAUTION

  Always have a helper present to assist you in guiding the vehicle onto the alignment rack.

- Check the alignment equipment manufacturer's manual to see if the vehicle's transmission should be set in park or neutral.

- Check to see when the calibration of the alignment heads was last checked and adjusted. If a long period of time has passed since adjustment, have them recalibrated before attempting alignment procedures.

  NOTE: Manufacturers service alignment heads periodically to make sure that alignment machine readings are accurate.

- Handle the alignment heads carefully. Careless handling can affect the calibration, causing the alignment machine readings to be inaccurate.

- Be sure that the alignment heads are correctly mounted to all wheels. Incorrectly mounting the heads could cause the alignment machine readings to be inaccurate. If the heads are not securely attached, they could fall and be damaged. If the heads are dropped, they must be recalibrated.

- Follow the instructions in the equipment manufacturer's manual to connect the cords, from the alignment heads to the alignment machine.

Guidelines for using dynamic alignment machines:

- Make sure the vehicle's wheels are correctly positioned on the rollers.

- Properly secure the vehicle on the alignment rack. Some racks do not have wheel stops, and the vehicle must be secured with chains.

EQUIPMENT AND MATERIALS

- Vehicle
- Appropriate service manual
- Alignment machine
- Alignment machine manual
- Other equipment and materials as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

JOB SHEET 2

ADJUST WHEEL ALIGNMENT

VI

OBJECTIVE 8B **Measure and adjust front-to-rear tracking.**

INTRODUCTION

Tracking is the alignment of the rear wheels with the front wheels. Improper tracking can be a result of misalignment, a shifted axle, or frame damage. For this reason, tracking should always be checked when you adjust wheel alignment. Axle offset, wheel setback, and axle side-set are all types of tracking problems. How these problems are corrected depends on the type of suspension and the exact cause of the problem. Incorrect tracking that cannot be corrected during wheel alignment indicates that other problems are present. The frame, axle, and suspension components should be thoroughly inspected and repaired if necessary.

There are several methods of detecting improper tracking. The best way to check tracking is to use a toe measuring device while the vehicle is on the alignment rack. The only alignment machines that can check tracking are those used for four-wheel alignment.

Tracking can be crudely checked by driving the vehicle from wet pavement onto dry pavement and observing the tracks left by the tires. Vehicles with tracking problems such as wheel setback will tend to pull to one side. However, it is not reliable to diagnose tracking problems with this method. A measuring stick can be used to measure tracking, but with this method, you must assume that the frame, axle, and suspension are all in good condition. The method is not dependable under most circumstances.

Adjusting tracking is similar to measuring and correcting toe setting. The type of suspension system and the conditions causing the incorrect tracking must be considered when deciding exactly how measurements and adjustments should be made. For example, in many situations all four wheels must be a certain distance from the vehicle center line, and the vehicle center line, geometric center line, and thrust line should be the same. This is called *geometric center line alignment*. In other instances, the rear wheels cannot be adjusted, so the front wheels are adjusted to be in line with the rear wheels. This is called *thrust line alignment* because the front wheels are aligned with the thrust line rather than the geometric center line.

Tracking is measured and adjusted before other alignment settings are measured and adjusted. There is an exception, however. If it is apparent that there is excessive toe-out or toe-in, toe should be adjusted *before* making tracking adjustments.

Because measuring and adjustment procedures differ, it is important that the steering and suspension technician follow the alignment equipment manufacturer's instructions when adjusting front-to-rear tracking.

EQUIPMENT AND MATERIALS

- Vehicle
- Appropriate service manual
- Alignment machine
- Alignment machine manual
- Other equipment and materials as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

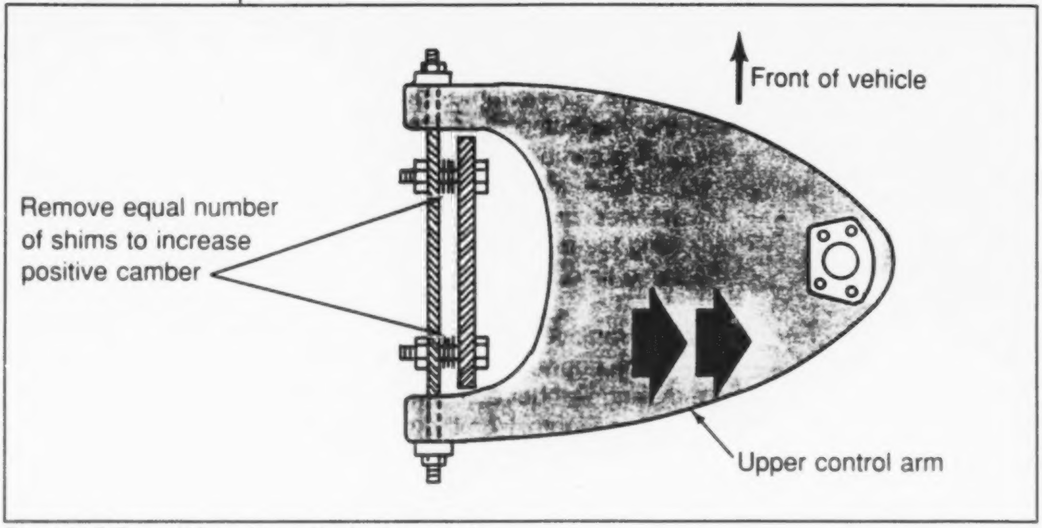
OBJECTIVE 8C **Measure and adjust camber.**

INTRODUCTION

Camber is one of three adjustable alignment angles. Although camber is adjustable on most types of vehicles, it is not adjustable on a few vehicles with MacPherson struts. Camber is normally the first alignment angle to be checked and corrected because changes in camber affect both caster and toe settings.

There are different camber adjustment methods for different vehicles. On vehicles with short-and-long-arm suspension systems, camber adjustments can be made at the upper control arm by inserting or removing shims, adjusting special cam bolts, or using special tools to change the control arm position. Each of these methods of adjustment affects the control arm position in the same manner. Moving the control arm inward causes the upper ball joint to be positioned more toward the center of the vehicle, thus making a negative change in camber. Just the reverse is true when the control arm is moved outward. Moving it outward causes a positive change in camber. (Figure 1)

FIGURE 1



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Camber adjustments on vehicles with MacPherson strut suspensions also vary. On some, camber is adjusted with a cam bolt at the point where the strut assembly connects to the steering knuckle. Turning the cam bolt causes the strut assembly to tilt either more inward or outward, depending upon which way the cam bolt is turned. On others, camber is adjusted at the upper strut mounting. Some vehicles have strut assemblies that are designed so that adjustments can be made at this mounting. The strut assemblies on other vehicles must be adapted by installing an adjustment kit or by making slots in the upper mounting area. Another type of adjustment is accomplished by adding shims between the axle and the spindle.

Whether or not camber is adjustable for a particular vehicle, it should always be checked and, if possible, adjusted to specifications. It is important for the steering and suspension technician to refer to the vehicle manufacturer's manual to see if camber can be adjusted and to find specifications for caster angle settings.

Although measuring and adjustment procedures vary from vehicle to vehicle and from one alignment machine to another, there are some basic guidelines that should be followed when measuring and adjusting camber. These guidelines are listed below.

Guidelines:

- Jounce the vehicle three times at the center of both the front and the rear bumpers to normalize vehicle ride height before measuring camber.

- Always measure and adjust caster and camber before adjusting toe-in. Caster and camber are normally adjusted at the same time.

- Insert or remove equal amount of shims to the front and the rear of the upper control arm connection to the frame if you are making camber adjustment with shims at the upper control arm. (See Figure 1 on the previous page.)

- Be sure that the vehicle is under no load or normal load when measuring and adjusting camber. Camber changes when weight is added to the vehicle, and the manufacturer's camber settings compensate for the weight that is normally added. Because the camber of the left wheel changes with the added weight of the driver, the specifications for the left camber setting are usually more positive than for the right camber setting.
- If camber is nonadjustable, and camber angle is not within specifications, check steering and suspension parts thoroughly before making a decision to replace them, especially if none of the parts appear to be excessively worn. Complete a SAI check at this point. (Job Sheet 5) Check to see if aftermarket adjustment kits or manufacturer's adjustment kits are available.
- Retorque all fasteners to specifications after all adjustments are complete.

Camber adjustments and specifications differ and so do the procedures for measuring camber using various alignment equipment. It is important that the technician always check the vehicle manufacturer's service manual to find the correct specifications and instructions for adjusting camber.

EQUIPMENT AND MATERIALS

- Vehicle
- Appropriate service manual
- Alignment machine
- Alignment machine manual
- Other equipment and materials as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

JOB SHEET 4

ADJUST WHEEL ALIGNMENT

VI

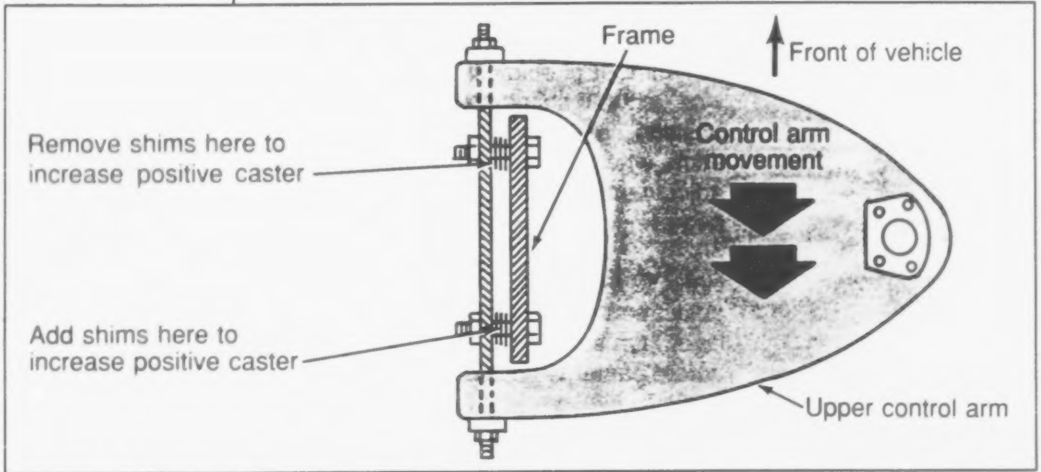
OBJECTIVE 8D **Measure and adjust caster and measure toe-out on turns.**

INTRODUCTION

Another alignment angle that should always be checked during alignment service is caster. Most alignment machines obtain caster measurements by measuring camber angle. This is done by measuring camber at two different points—with the wheels turned a certain number of degrees to the left and then turned the same number to the right. The actual caster reading is determined by the amount of camber change that occurs when the wheels are turned.

As vehicle designs vary, so do types of caster adjustments. Some vehicles are even constructed so that caster is set into the front axle assembly and is not adjustable. On other vehicles, such as those with short-and-long-arm suspension systems, caster adjustments are made by changing the position of the upper control arm. This can be done by installing a special adjustment kit that includes the installation of cam bolts to the inner shaft of the upper control arm. On some vehicles, special tools are used to reposition the control arm and adjust caster. Other vehicles are adjusted by inserting or removing shims between the upper control arm shaft and the frame. Adding shims under the front bolt increases caster; adding them under the rear bolt increases camber. (Figure 1) Note, however, that this is reversed if the control arm pivot shaft is inboard of the frame bracket.

FIGURE 1


Frame
Front of vehicle
Remove shims here to increase positive caster
Control arm movement
Add shims here to increase positive caster
Upper control arm

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On other vehicles with short-and-long-arm suspension and on some vehicles with MacPherson-strut suspension, caster angles are changed by adjusting strut rods. The caster on some vehicles with MacPherson struts is either nonadjustable, adjustable at the upper mount of the strut assembly, or adjustable by adapting the strut assembly connections by installing aftermarket kits.

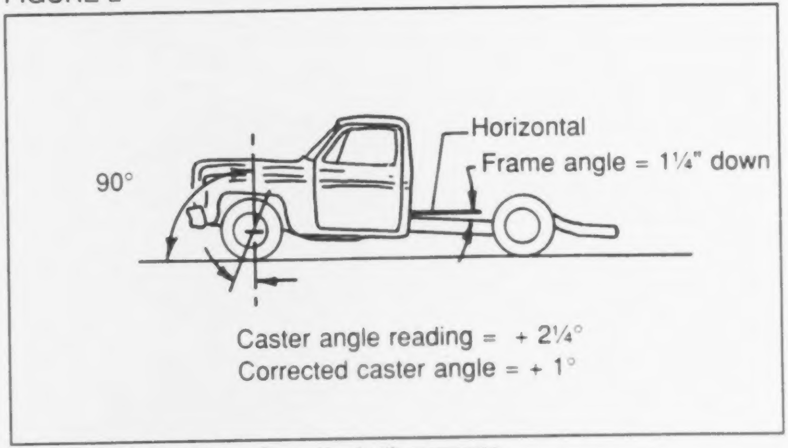
Toe-out on turns is nonadjustable. However it should always be checked, and the angle readings compared to the vehicle manufacturer's specifications. Readings that are not within specifications indicate that other steering arms are bent or otherwise damaged.

Although adjustments and specifications for caster and toe-out on turns vary, there are some guidelines that should be followed whenever checking and adjusting these alignment angles.

Guidelines:

- Jounce the vehicle three times at the center of both the front and the rear bumpers to normalize vehicle ride height before measuring caster.
- Be sure the vehicle is loaded as it normally is when adjusting the caster. A heavy load at the rear of the vehicle will raise the front of the vehicle, changing the caster angle. A vehicle that is normally operated with a heavy load should have the caster adjusted with the vehicle under heavy load.
- If you are only making a caster adjustment at the rear, remove a number of shims from the front of the control arm equal to the number of shims inserted at the back of the control arm or vice versa, if shims are used to adjust caster in the other position. By keeping the total number of inserted shims the same when making the caster adjustment, the camber adjustment cannot be affected. (See Figure 1 on the previous page.)
- Refer to the vehicle manufacturer's service manual for adjustments to the caster angle if the vehicle frame is not level. On some trucks, the frame angle must be measured before caster is adjusted. (Figure 2)

FIGURE 2



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- Check the vehicle manufacturer's specifications carefully to see whether different caster angle specifications are given for vehicles with power steering and vehicles with manual steering. Because those with power steering are easier to steer, the caster angle is usually more positive. Conversely, a less positive caster angle allows a vehicle with manual steering to be steered more easily.

- If caster is nonadjustable and caster angle is not within specifications, check steering and suspension parts thoroughly before making a decision to replace them, especially if none of the parts appear to be excessively worn. Check to see if aftermarket adjustment kits or manufacturer's adjustment kits are available.

- Refer to the vehicle manufacturer's specifications when measuring toe-out on turns. Some manufacturers specify turning one wheel 20 degrees to the outside and taking the angle reading of the other wheel. Others specify turning the wheel 15 degrees or 18 degrees and taking the angle reading of the other wheel.

- Reinspect the steering arm if the measurement of toe-out on turns is not within specifications.

- Retorque all fasteners to specifications after all adjustments are complete.

EQUIPMENT AND MATERIALS

- Vehicle
- Appropriate service manual
- Alignment machine
- Alignment machine manual
- Other equipment and materials as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

OBJECTIVE 8E **Measure steering axis inclination.**

INTRODUCTION

Two alignment angles that should be measured even though they are nonadjustable are the angle of steering axis inclination, or SAI, and the included angle. The SAI angle is that angle between a vertical line and a line running through the center of the upper and lower pivot points (usually the ball joints) of the steering support when viewed from the front. An SAI reading that is not within specifications is an indication that another problem is present.

The purpose of measuring the SAI is to decrease the need for excessive camber settings. It is usually measured when camber is measured. The reading is obtained by measuring the camber angle with the wheel turned outward a specified amount and again with the wheel turned inward a specified amount. The SAI angle can be measured in this manner because the SAI angle causes the spindle to change positions—point more upward or downward—as the wheel is turned.

On alignment machines that measure the included angle (the SAI angle plus the camber angle), the camber angle reading must be subtracted from the included angle reading, leaving the SAI angle. The SAI angle can then be compared with the vehicle manufacturer's specifications. If the camber angles on both sides are equal, then the SAI can be used to diagnose problems with suspension components.

The procedures for obtaining SAI measurements vary from one alignment machine to another. However, there are some guidelines that should be observed whenever measuring this alignment angle.

Guidelines:

- Jounce the vehicle three times at the center of both the front and the rear bumpers to normalize vehicle ride height before measuring the steering axis inclination.
- Be sure to have the brake pedal firmly depressed to prevent any wheel rotation. Since the alignment heads are usually connected to the wheel assembly rather than to the spindle, any rotation of the wheel can affect the SAI readings.

- Inspect steering and suspension components, especially the spindle, steering knuckle, and struts, if the SAI readings are not within specifications. Replace any bent or damaged components before remeasuring the alignment angles.

Procedures for measuring steering axis inclination differ depending on the type of alignment machine used. The technician should always follow the alignment machine manufacturer's instructions for measuring SAI and should refer to the vehicle manufacturer's service manual for SAI specifications.

EQUIPMENT AND MATERIALS

- Vehicle
- Appropriate service manual
- Alignment machine
- Alignment machine manual
- Other equipment and materials as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

JOB SHEET 6

ADJUST WHEEL ALIGNMENT

VI

OBJECTIVE 8F

Measure and adjust toe.

INTRODUCTION

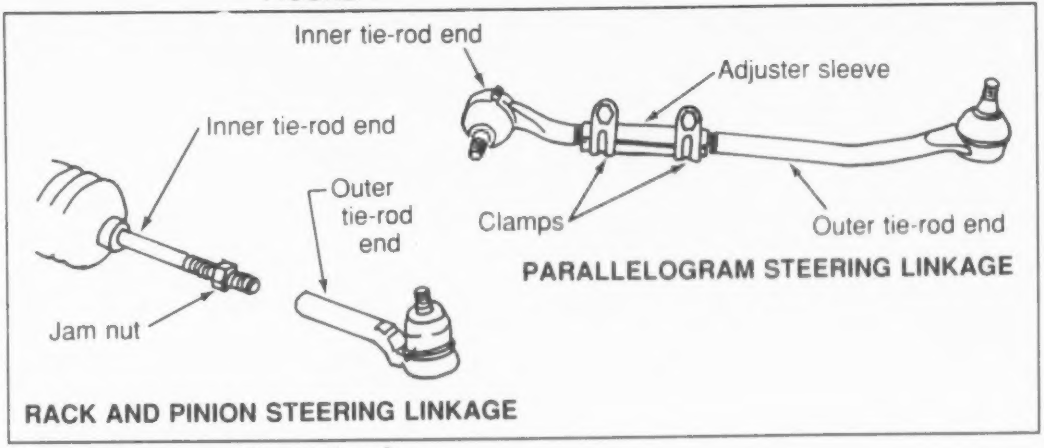
The alignment angle that is adjusted last is toe. This is because changes in caster and camber settings can affect the toe setting. Properly adjusted toe aids steering effort and provides increased directional control of the vehicle.

Vehicle manufacturers list the specifications for the total toe setting. This total is the sum of the toe angles for each wheel. Since most vehicles should have wheels that toe-in rather than toe-out, this measurement is usually expressed as *total toe-in* or simply *toe-in*. Toe settings can be expressed as a measurement of distance between the centers of the front of the tires compared to the centers of the rear of the tires and are given in inches or millimeters. Settings for toe can also be expressed as angle measurements given in degrees.

Toe can be measured using various types of equipment. Mechanical toe gauges can be used to measure the distance between lines drawn on the centers of each tire tread. An optical toe gauge uses a beam of light projected onto a mirror which reflects the light beam onto a chart containing toe readings. Other alignment equipment shows the toe setting on some type of meter or gauge. Some equipment is computerized and provides the reading on a computer display screen. Using computerized alignment machines has an advantage over the other methods in that the changing toe settings are displayed as the toe angle is being adjusted.

Since different equipment can be used to measure toe, the steering and suspension technician must follow the procedures outlined in the various equipment manufacturers' manuals. However, the adjustment procedures for all types of vehicles is basically the same. To increase or decrease toe, the tie-rod assemblies must be shortened or lengthened. On vehicles having parallelogram steering, the tie-rod adjuster sleeve is turned one way or the other. (See Figure 1 on the following page.) On those with rack-and-pinion steering, the tie-rod assemblies are shortened or lengthened by loosening the jam nuts on the tie rod (Figure 1) and rotating the inner tie rod until the toe angle is within specifications. Refer to Job Sheet 5 in Unit 2, *Service Steering Systems*, for more information about tie-rod end adjustment.

FIGURE 1


Inner tie-rod end
Adjuster sleeve
Inner tie-rod end
Outer
tie-rod
end
Clamps
Outer tie-rod end
PARALLELOGRAM STEERING LINKAGE
Jam nut
RACK AND PINION STEERING LINKAGE

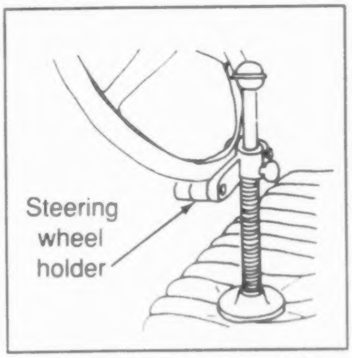
Adapted with permission of Chrysler Motor Corp.

Guidelines for adjusting toe on vehicles with either type of steering system are listed below and on the following pages.

Guidelines:

- Use a steering wheel holder as shown in Figure 2 to keep the steering wheel in a centered position while you are adjusting toe.

FIGURE 2


Steering
wheel
holder

From *Steering, Suspension, and Wheel Service, Unit 4*, © 1980 by State of Florida Department of State. Used with permission of Florida Department of State.

- Shorten tie-rod assemblies to increase toe-in and lengthen assemblies to decrease toe-in if the steering knuckle is attached to the front of the spindle assembly. Lengthen tie-rod assemblies to increase toe-in and shorten tie-rod assemblies to decrease toe-in if the steering knuckle is attached to the rear of the spindle assembly.

- Check the vehicle manufacturer's service manual to see if there are different toe-in setting specifications for radial and bias-belted tires.

  NOTE: Different specifications are more commonly given for older model vehicles because these vehicles were usually equipped with bias-belted tires. Today radial tires are popular, and the vehicle manufacturers' toe-in specifications for newer vehicles are for vehicles equipped with radial tires.

- Center the steering wheel, after toe adjustments are complete, by lengthening the tie-rod assembly having the least number of threads showing and shortening the opposite tie-rod assembly. Continue lengthening and shortening by equal amounts until the steering wheel is centered.

This job sheet will give you practice measuring and adjusting toe.

EQUIPMENT AND MATERIALS

- Vehicle
- Appropriate service manual
- Alignment machine
- Alignment machine manual
- Other equipment and materials as required by procedure

PROCEDURE

NOTE: Refer to the appropriate service manual for make and model as equipped.

ADJUST WHEEL ALIGNMENT

JOB SHEET 1

Set up a wheel-alignment machine for a two-wheel and a four-wheel alignment procedure.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	______	______
2. Properly prepared vehicle.	______	______
3. Positioned vehicle on alignment rack correctly.	______	______
4. Set up alignment machine for two-wheel alignment procedures following procedures outlined in alignment equipment manufacturer's manual.	______	______
5. Set up alignment machine for four-wheel alignment procedures following procedures outlined in alignment equipment manufacturer's manual.	______	______
6. Observed safety rules and precautions.	______	______
7. Cleaned work area and returned equipment and materials to proper storage.	______	______

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

ADJUST WHEEL ALIGNMENT

JOB SHEET 2

Measure and adjust front-to-rear tracking.

STUDENT'S NAME ______________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly prepared vehicle and alignment equipment.	_____	_____
3. Measured front-to-rear tracking following procedure outlined in alignment machine manufacturer's manual.	_____	_____
4. Correctly determined whether to do geometric center line alignment or thrust line alignment.	_____	_____
5. Adjusted front-to-rear tracking following procedure outlined in alignment machine manufacturer's manual.	_____	_____
6. Observed safety rules and precautions.	_____	_____
7. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

____

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

PRACTICAL TESTS

ADJUST WHEEL ALIGNMENT

VI

JOB SHEET 3

Measure and adjust camber.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly prepared vehicle and alignment equipment.	_____	_____
3. Measured camber following procedures outlined in alignment equipment manufacturer's manual.	_____	_____
4. Adjusted camber to vehicle manufacturer's specifications.	_____	_____
5. Used tools and equipment correctly.	_____	_____
6. Correctly completed Wheel Alignment Check Sheet.	_____	_____
7. Completed service correctly.	_____	_____
8. Observed safety rules and precautions.	_____	_____
9. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards..	4	3	2	1

EVALUATOR'S COMMENTS

____

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 4

Measure and adjust caster and measure toe-out on turns.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME __________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly prepared vehicle and alignment equipment.	_____	_____
3. Measured caster following procedures outlined in alignment equipment manufacturer's manual.	_____	_____
4. Adjusted caster to vehicle manufacturer's specifications.	_____	_____
5. Measured toe-out on turns following outlined procedures.	_____	_____
6. Compared measurement of toe-out on turns with vehicle manufacturer's specifications.	_____	_____
7. Completed service correctly.	_____	_____
8. Observed safety rules and precautions.	_____	_____
9. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

ADJUST WHEEL ALIGNMENT

JOB SHEET 5 **Measure steering axis inclination.**

STUDENT'S NAME ________________ DATE ____________

EVALUATOR'S NAME ________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	_____	_____
2. Properly prepared vehicle and alignment equipment.	_____	_____
3. Measured steering axis inclination following procedures outlined in alignment equipment manufacturer's manual.	_____	_____
4. Compared measurement of steering axis inclination with vehicle manufacturer's specifications and correctly determined whether measurement was within specifications.	_____	_____
5. Used tools and equipment correctly.	_____	_____
6. Correctly completed Wheel Alignment Check Sheet.	_____	_____
7. Completed service correctly.	_____	_____
8. Observed safety rules and precautions.	_____	_____
9. Cleaned work area and returned equipment and materials to proper storage.	_____	_____

EVALUATOR'S COMMENTS

____

____

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PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:				
Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

____

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____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

JOB SHEET 6

Measure and adjust toe.

STUDENT'S NAME ____________________ DATE ______________

EVALUATOR'S NAME ____________________ ATTEMPT NO. _____

INSTRUCTIONS

When you are ready to perform this task, ask your instructor to observe the procedure and complete this form. All items listed under Process Evaluation must receive a "Yes" for you to receive an acceptable performance evaluation.

PROCESS EVALUATION

Evaluator Note: Write a check mark in the "Yes" or "No" blanks to designate whether or not the student has satisfactorily achieved each step in this procedure. If the student is unable to achieve this competency, have the student review the materials and try again.

The student:	YES	NO
1. Obtained proper equipment and materials.	______	______
2. Properly prepared vehicle and alignment equipment.	______	______
3. Measured toe following procedures outlined in alignment equipment manufacturer's manual.	______	______
4. Adjusted toe to vehicle manufacturer's specifications.	______	______
5. Used tools and equipment correctly.	______	______
6. Correctly completed Wheel Alignment Check Sheet.	______	______
7. Completed service correctly.	______	______
8. Observed safety rules and precautions.	______	______
9. Cleaned work area and returned equipment and materials to proper storage.	______	______

EVALUATOR'S COMMENTS ____

____

PRODUCT EVALUATION

Evaluator Note: Rate the student on the following criteria by circling the appropriate numbers. Each criterion must receive a rating of "3" or higher to demonstrate student mastery. (See Performance Evaluation Key.) A student who is unable to demonstrate mastery should review the materials and submit another product for evaluation.

Criteria:

Product meets manufacturer's installation specifications.	4	3	2	1
Product meets manufacturer's adjustment specifications.	4	3	2	1
Product includes proper components/materials.	4	3	2	1
Product appearance meets performance requirements.	4	3	2	1
Product appearance meets industry standards.	4	3	2	1

EVALUATOR'S COMMENTS

____

____

____

AVERAGE RATING

Evaluator Note: To obtain an average rating for the competency profile, total the designated points in Product Evaluation and divide by the total number of criteria. Circle the rating on the Performance Evaluation Key below.

PERFORMANCE EVALUATION KEY

4 — Skilled — Can perform job with no additional training.
3 — Moderately skilled — Has performed job during training program; limited additional training may be required.
2 — Limited skill — Has performed job during training program; additional training is required to develop skill.
1 — Unskilled — Is familiar with process, but is unable to perform job.

WRITTEN TEST

ADJUST WHEEL ALIGNMENT

VI

NAME ______________________________ SCORE ________

OBJECTIVE 1

Select definitions of terms associated with wheel alignment. Choose the definitions that best define the following terms and then write the correct letters in the blanks.

______1. **vehicle center line**

A. Line passing through the midpoint of the front and rear axles of the vehicle
B. Line dividing the vehicle into two sections equal in weight
C. Line of drive direction passing through the midpoint of the rear axle of the vehicle
D. Line passing through the center of the vehicle lengthwise

______2. **axle offset**

A. Condition in which the geometric center line is not parallel to or the same as the thrust line; the rear axle is not perpendicular to the center line
B. Condition in which one wheel spindle is not aligned with the opposite wheel spindle, but a line through the spindle of each wheel is perpendicular to the center line of the vehicle
C. Condition in which vehicle center line and geometric center line are not the same line
D. Condition in which the axles are not parallel

______3. **static alignment machine**

A. Machine that measures the alignment angles of the wheels while the wheels are stationary; takes alignment readings from the spindle
B. Machine that measures the alignment angles of the wheels while the wheels are rotating; takes alignment readings from tire contact with the road surface
C. Machine that measures alignment angles and uses a computer graphic display to indicate readings; takes alignment readings from tire contact with the road surface
D. Machine that measures the angles of the wheels while the wheels are stationary and then compares them to the angles measured while the wheels are in motion

______4. **geometric center line**

A. Line passing through the center of the vehicle lengthwise
B. Line passing through the midpoint of the front and rear axles of the vehicle
C. Line of drive direction passing through the midpoint of the rear axle of the vehicle
D. Line of drive direction passing through the midpoint of the front axle of the vehicle

______5. **axle side-set**

A. Condition in which the geometric center line is not parallel to or the same as the thrust line; the rear axle is not perpendicular to the center line
B. Condition in which one wheel spindle is not aligned with the opposite wheel spindle, but the line through the spindle of each wheel is perpendicular to the center line
C. Condition in which the vehicle center line and the geometric center line are not the same line
D. Condition in which the rear wheels are farther from the vehicle center line than are the front wheels

_____6. **dynamic alignment machine**

A. Machine that measures the alignment angles of the wheels while the wheels are stationary; takes alignment readings from the spindle
B. Machine that measures the alignment angles of the wheels while the wheels are rotating; takes alignment readings from tire contact with the road surface
C. Machine that measures the alignment angles of the wheels while the wheels are stationary and then compares them to the angles measured while the wheels are in motion
D. Machine that measures alignment angles and uses a computer graphic display to indicate readings

_____7. **thrust line**

A. Line passing through the center of the vehicle lengthwise
B. Line passing through the midpoint of the front and rear axles of the vehicle
C. Line of drive direction passing through the midpoint of the rear axle of the vehicle
D. Line of drive direction passing through the midpoint of the front axle of the vehicle

_____8. **wheel setback**

A. Condition in which the geometric center line is not parallel to or the same as the thrust line; the rear axle is not perpendicular to the center line
B. Condition in which resistance forces the axles to bend slightly
C. Condition in which the vehicle center line and the geometric center line are not the same line
D. Condition in which one wheel spindle is not aligned with the opposite wheel spindle, but a line through the spindle of each wheel is perpendicular to the center line of the vehicle

______9. **computerized alignment machine**

A. Machine that measures the alignment angles with computerized devices; takes alignment readings only from the spindle
B. Machine that measures alignment angles and uses a computer graphic display to indicate readings
C. Machine that measures the alignment angles of the wheels while the wheels are stationary; displays readings on an analog type display
D. Machine that uses computerized devices to measure alignment angles by measuring tire contact with the road surface

______10. **toe-out on turns**

A. The diameter of the circle made by the outer tire during a full turn
B. Condition in which the geometric center line is not parallel to or the same as the thrust line
C. Degree of wheel rotation in turns
D. A characteristic of steering systems during turns in which the inner wheel turns more sharply than the outer wheel

______11. **turning radius**

A. The diameter of the circle made by the outer tire during a full turn
B. The diameter of the circle made by the inner tire during a full turn
C. The degree of wheel rotation in turns
D. The position of the front tires in relation to each other during turns

OBJECTIVE 2

State the purposes of wheel alignment. Write the purposes in the following blanks.

1. ____

____

2. ____

____

3. ____

____

OBJECTIVE 3 **List alignment angles.** Write the names of the alignment angles in the following blanks.

1. ____
2. ____
3. ____
4. ____
5. ____
6. ____

OBJECTIVE 4 **List in order the steps for measuring and adjusting wheel alignment angles.** Write the steps in the blanks below.

1. ____
2. ____
3. ____
4. ____
5. ____
6. ____
7. ____
8. ____

OBJECTIVE 5

Match types of wheel alignment devices to their functions.
Write the correct letters in the blanks.

______1. Measures camber and caster by using light beams from projectors attached to the wheels

______2. Measures toe setting using a sensor mounted to an adaptor attached to the wheel rim

______3. Measures caster, camber, and steering axis inclination by using bubble-level indicators

______4. Measures toe-out on turns by using turning devices with gauges under the front wheels; also used in conjunction with other devices to measure caster

______5. Measures sideways drag of tires, indicating whether a vehicle has excessive toe-in or toe-out

______6. Measures the amount of toe-in or toe-out by measuring the distance between lines drawn on the center of the tire treads

______7. Measures toe, caster, and camber electronically by spinning the wheels with sets of rollers

______8. Measures toe setting by using a light beam, mirror, and scale

A. Dynamic wheel aligner

B. Electronic toe gauge

C. Light beam alignment tester

D. Mechanical gauge

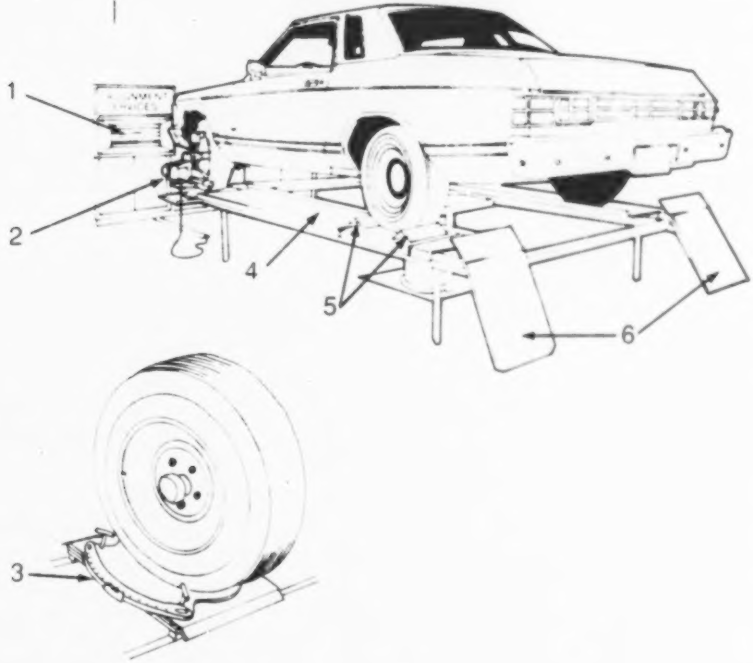
E. Mechanical toe gauge

F. Optical toe gauge

G. Scuff gauge

H. Turning radius gauge

OBJECTIVE 6 **Identify the parts of a wheel alignment machine.** Write the letter of the correct part in the blank.



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______1. A. Alignment head

______2. B. Alignment rack

______3. C. Alignment readings display

______4. D. Ramps

______5. E. Turning radius gauge

______6. F. Wheel chocks

WRITTEN TEST ANSWERS

ADJUST WHEEL ALIGNMENT

VI

OBJECTIVE 1

1. D
2. A
3. A
4. B
5. C
6. B
7. C
8. D
9. B
10. D
11. A

OBJECTIVE 2

The answers should include all of the following:

- To insure efficient steering and proper directional control
- To prevent abnormal tire wear
- To insure proper tracking of the wheels

OBJECTIVE 3

The answers should include all of the following

- Caster
- Camber
- Steering axis or kingpin inclination (SAI or KPI)
- Turning radius
- Toe
- Toe-out on turns

OBJECTIVE 4

NOTE: The following steps *must* be listed in the order shown.

1. Measure rear camber and toe; record measurements
2. Measure front camber, caster, and toe; record measurements
3. Compare the measurements to manufacturer's specifications to determine required adjustments
4. Adjust rear camber to specifications
5. Adjust rear toe to specifications
6. Adjust front camber and caster to specifications
7. Adjust front toe to specifications
8. Remeasure all alignment angles

OBJECTIVE 5

1. C
2. B
3. D
4. H
5. G
6. E
7. A
8. F

OBJECTIVE 6

1. C
2. A
3. E
4. B
5. F
6. D

STEERING AND SUSPENSION SPECIALIST

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	READING SKILLS																							WRITI												
	Reading Comprehension									Research and Reference								Functional Reading						Language		Composition								Resea		
UNITS OF INSTRUCTION STATE/LOCAL CODES*	Gain factual information	Distinguish fact, opinion and inference	Recognize stereotyping and bias	Recognize propaganda	Analyze cause and effect	Draw conclusions	Make generalizations	React to written material	Apply word analysis techniques	Select useful resources	Locate resources	Find materials in library	Use standard references	Use in-book reference tools	Use audiovisual media	Use computer data base	Use magazines and newspapers	Interpret forms and records	Follow written instructions	Interpret graphics and symbols	Use content area vocabulary	Interpret abbreviations/acronyms	Read aloud	Use standard grammar and correct spelling, punctuation, and capitalization	State ideas clearly	Use complete sentences	Develop preliminary outline	Use topic sentences	Use introductory/closing paragraphs	Compose reports	Compose essays	Proofread and edit	Construct graphics and symbols	Take notes	Use notecards	Create bibliography
Serv. Tap. R. W. Bearings	●					●							●	●					●	●	●															
Service Steering Systems	●					●							●	●					●	●	●															
Service Front Suspension Sys.													●						●	●	●	●														
Service Rear Suspension Sys.	●												●						●	●	●															
Perform Pre-Alignment Insp.	●					●							●	●					●	●	●			●	●											
Adjust Wheel Alignment						●							●						●	●	●	●														

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MC BASIC SKILLS DOCUMENTATIO

ING SKILLS									MATH SKILLS																																						
ch		Functional Writing							Operation and Calculation														Math Application											Data Analysis and Display													
Use footnotes	Outline material	Complete forms and records	Write instructions	Write letters	Write job applications	Write resumes	Use word processing	Use computer graphics	Round off numbers	Estimate answers	Use scientific notations	Use exponential notations	Calculate with whole numbers	Calculate with fractions	Calculate with decimals	Convert whole numbers to fractions	Convert whole numbers to decimals	Solve numerical expressions	Solve formulae and equations	Obtain squares and square roots	Convert units of measure	Perform metric calculations	Solve word problems	Select/apply mathematical formula	Select/apply mathematical procedure	Use English and metric measures	Solve time/rate/distance problems	Solve ratio-proportion problems	Solve percent problems	Apply techniques of scaling	Apply algebra principles	Apply geometry principles	Apply trigonometry principles	Interpret charts and tables	Interpret graphs (type)	Collect/record data	Apply sampling techniques	Apply principles of probability	Construct charts and tables	Construct graphs	Calculate statistics	Interpret statistics	Interpret blueprints plans	Make measurements	Perform banking transactions	Make change	Solve practical problems
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SCIENCE SKILLS

Functional Math										General Science									Life Science							Physical Science					Earth Science							
Calculate gross earnings	Solve income expense problems	Prepare a budget	Calculate interest	Solve interest problems	Calculate sales tax	Determine income tax	Use calculator for computation	Use computer for computation	Use computer spreadsheets	Apply computing skills	Apply scientific method of inquiry	Conduct experiments	Investigate science ethics	Investigate science history	Investigate/apply economics in technology	Use scientific instruments	Investigate/apply technology	Collect specimens	Identify/classify living organisms	Investigate biological history of the earth	Investigate food chains, webs, pyramids	Investigate/apply principles of human development	Investigate/apply principles of genetics/heredity	Investigate/apply principles of anatomy physiology	Investigate health issues	Analyze/classify matter	Investigate forms changes of matter	Investigate forms/changes of energy	Investigate/apply chemical properties	Investigate/apply physical laws	Investigate physical characteristics of the earth	Investigate geological history of the earth	Investigate physical forces acting on the earth	Solve problems of longitude, latitude, and time zones	Investigate conservation of physical resources	Investigate conservation of living resources	Investigate issues of environmental impact	Apply science principles to environmental issues
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ORAL COMMUNICATIONS SKILLS

UNITS OF INSTRUCTION STATE/LOCAL CODES*	Oral Presentation								
	Make informative presentations	Make persuasive presentations	Present personal opinion/viewpoint	Use good speaking techniques	Select/use words effectively	Use effective body language	Present appropriate appearance	Integrate audio and/or visual materials in oral presentations	Adapt presentation to specific audience
Serv. Tap. R. W. Bearings			●						
Service Steering Systems			●						
Service Front Suspension Sys.			●						
Service Rear Suspension Sys.			●						
Perform Pre-Alignment Insp.			●						
Adjust Wheel Alignment			●						

UNITS OF INSTRUCTION STATE/LOCAL CODES*	Listening				Interactive Communication									
	Apply active listening skills	Distinguish fact, opinion, and interference	Draw conclusions/make generalizations	Analyze/identify point of view	Give/follow oral directions	Apply questioning techniques	Conduct/receive interviews	Analyze/apply nonverbal communication	Work effectively in a group	Communicate with clients/customers/patients	Communicate with co-workers	Communicate with supervisors	Communicate with professional colleagues/associates	Apply telephone etiquette
Serv. Tap. R. W. Bearings	●	●	●	●					●					
Service Steering Systems	●	●	●	●					●					
Service Front Suspension Sys.	●	●	●	●					●					
Service Rear Suspension Sys.	●	●	●	●					●					
Perform Pre-Alignment Insp.	●	●	●	●					●					
Adjust Wheel Alignment	●	●	●	●					●					

INTERPERSON

UNITS OF INSTRUCTION STATE/LOCAL CODES*	General Relating																
	Investigate/apply communication process models	Analyze/apply nonverbal communication	Investigate/apply cross-cultural communication	Interact with co-workers	Interact with supervisors	Interact with clients/customers/patients	Interact with professional colleagues/associates	Interact with family/friends	Participate in group activities	Participate in industrial relations functions	Identify personal values/attitudes	Apply information to life experiences	Identify values/attitudes	Identify needs/drives	Select/apply appropriate behavior	Investigate/identify personal styles	Investigate/identify group
Serv. Tap. R. W. Bearings																	
Service Steering Systems				●													
Service Front Suspension Sys.																	
Service Rear Suspension Sys.																	
Perform Pre-Alignment Insp.																	
Adjust Wheel Alignment																	

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AL OR RELATING SKILLS																		CREATIVE THINKING/ PROBLEM SOLVING SKILLS																				EMP							
Teamwork Cooperation											Leadership Influence							Cognitive Activities																				Job Search Selection							
corporate climate	Give/receive feedback	Identify hidden purposes	Investigate/apply group dynamics	Control undesirable/inappropriate behavior	Resolve conflicts	Clarify goals/objectives	Devise "win/win" situations	Build consensus	Generate ideas	Present point of view	Analyze/apply leadership styles	Analyze/apply management styles	Obtain confidence of others	Develop esteem in self/others	Persuade others	Analyze/apply motivation techniques	Provide positive coaching	Collect/record information	Identify critical elements/issues	Define a problem	Identify underlying causes	Apply a problem-solving model	Analyze/synthesize information	Identify/analyze underlying assumptions	Draw conclusions	Predict results/outcomes	Identify/evaluate consequences	Identify/develop alternatives	Evaluate alternatives	Select an alternative	Devise a solution	Create a finished product	Apply intuitive creative thinking processes	Transfer knowledge/training to new situations	Apply new technology	Develop an action plan	Evaluate results/outcomes	Analyze personal occupational aptitudes/preferences	Investigate employment prospects of a career field/occupation	Investigate training requirements for a career field/occupation	Investigate benefits of a career field/occupation	Compare/evaluate career options	Develop personal career path	Locate appropriate jobs	Analyze duties/requirements/benefits of specific job
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OYABILITY SKILLS

SOCIAL STUDIES SKILLS

Job Acquisition Development														Information Analysis						Social Studies Application										Functional Social Studies														
Master specific job task/procedure	Fill in job related applications	Write letter of application	Write personal resume	Interview for a job	Apply business etiquette	Practice good work habits/attitudes	Develop good personal presentation	Develop self-confidence/esteem	Develop effective leadership	Deal effectively with supervisors	Deal effectively with co-workers	Deal effectively with professional colleagues/associates	Deal effectively with customers/clients	Collect/record data	Interpret graphical information	Construct graphical information	Interpret maps/globes	Interpret statistical information	Analyze/interpret demographic information	Investigate/apply U.S. history	Investigate/apply world history	Investigate/apply U.S. geography	Investigate/apply world geography	Investigate/apply principles of government/politics	Investigate/apply principles of economics	Investigate/apply principles of ethics	Investigate/apply principles of psychology	Investigate/apply principles of sociology	Investigate/apply cross-cultural studies	Practice responsible personal economics	Prepare a personal budget	Use credit responsibly	Practice good work ethics	Participate in industrial relations	Interact with people of different races/cultures	Investigate/participate in government	Investigate/apply American legal practices	Select/use sources of information on current events	Analyze current events	Analyze consumer issues	Analyze social issues	Analyze conservation/ecology issues	Analyze social impact of science/technology	Analyze economic impact of science/technology
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